HISTORY

OF THE

PROGRESS

AND

PRESENT STATE

OF

ANIMAL CHEMISTRY.

BY

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IN THREE VOLUMES.

VOL. II.

London:

PRINTED FOR J. JOHNSON, ST. PAUL'S CHURCHYARD,

By J. Crowder and E. Hemſted, Warwick Square.

1803.

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THE

HISTORY

OF

ANIMAL CHEMISTRY.

OILS.

UNDER this article are to be included all thofe animal fubftances that have an unctuous or greafy feel when rubbed between the fingers, are more or lefs eafily made to inflame, and when united with certain bodies, as for inftance, cauftic alkalis, form foap; an acid may likewife be extracted from them. They are in general much lefs fluid than the fat oils of plants, and fome of them in a concrete ftate, feem to have undergone a fpecies of cryftallization. Animal oils.

It appears, that almoft all animal fubftances are capable of being converted into a more or lefs concrete oil poffeffing the above properties, by depriving them of certain of their component parts; this takes place in a natural way in cemeteries, where large heaps of animal bo-

dies are amaſſed together; or this effect may be produced artificially, as by means of the nitrous acid; or by placing animal ſubſtances in ſuch a ſituation as to give the carbon and hydrogen an opportunity of forming an intimate union; hence in the diſtillation of animal ſubſtances the more or leſs quantity of fluid oil obtained is ſaid to be owing to this union of it's two component parts by the aid of heat.

Varieties. The oil of animals differs very much in conſiſtence; in the herbivorous and frugivorous tribes it is firm and ſolid, and is called *ſuet*; it is leſs concrete in the carnivorous claſs, in birds and in the pig, in which it is called *greaſe* and *lard*, as bear's greaſe, gooſe greaſe, and hog's lard; it is ſtill leſs ſo in milk, where it is called *butter*, and in the bone, called *marrow*, whilſt in the palmata and cetacea claſſes, and in fiſh it is nearly fluid, and is called *blubber* and *oil*. It is likewiſe leſs ſolid and concrete in the living than in the dead animal, and it varies even according to the parts, thus it is more ſolid near the kidneys and beneath the ſkin, and leſs firm between the muſcular fibres or near the moveable viſcera, ſuch as the heart, ſtomach, and inteſtines. This more or leſs concrete ſtate which an animal oil is ſubject to, is ſaid to be owing to the abſorption of oxygen, it has likewiſe been ſaid to ariſe more particularly in fat from the ſebacic acid.

Abounds more or leſs in different animals and parts. Animal oil is found to vary in quantity in different claſſes of animals. On comparing the quantity of it with the bulk of the body, it is more abundant in the cetaceous claſs than in amphibious quadrupeds, and more ſo in the laſt than in the frugivorous claſs. Carnivorous animals have the eaſt quantity. Laſtly, it is more abundant in winter than in ſummer, and appears deſtined to maintain the heat in thoſe regions where it is placed, and to contribute to the nouriſhment of animals, as is obſervable in bears, the mountain rat, the dormouſe, and in general in all

animals liable to long abſtinence. In man and ſome other animals it accumulates internally to preſerve the heat of the principal organs of life as age advances. It is found more abundantly in ſome parts than in others. In quadrupeds, and birds, and in the human body, it is depoſited in pretty conſiderable quantity near the kidneys, under the ſkin, in the orbits of the eyes, in the epiploon, and ſometimes at the point of the heart. In man there is none about the legs, the penis, and the brain. In the cold-blooded and cetaceous claſſes, the cavity of the cranium forms one of it's reſervoirs, and it is mixed with the parenchyma of the liver. According to Fourcroy, it is found in reptiles, inſects, and worms, but in theſe animals it only accompanies the viſcera of the lower belly, where it is placed in the form of knots, whilſt on the muſcles and under the ſkin, it is only met with in ſmall quantities. It forms one half of the liver of the ray.

Having made theſe preliminary obſervations, animal oils may be divided into *ſpermaceti*, *fat*, *fiſh or thran oil*, *and the empyreumatic oil*, extracted by diſtillation from all animal ſubſtances.

Spermaceti. This white ſubſtance, improperly called ſpermaceti, is a concrete, oily, cryſtalline matter, conſiſting of ſmall ſhining ſemitranſparent ſcales, very brittle, of a fatty ſavour, and tallowy ſmell. It is found in very large quantities in the cranium of that ſpecies of fiſh called by Linnæus, the phyſeter macrocephalus; cacholot, by the French; and the ſpermaceti whale, by the Engliſh; it is likewiſe found in leſs quantity in the phyſeter catodone, micrope, and curſione. Spermaceti.

Since this matter in it's natural ſtate is mixed with a good deal of oily ſubſtance, the cuſtom was to put it into a woollen bag, and let the fluid part run through, or make uſe of preſſure, whilſt the more fixed oil was converted into a ſoap by means of alkaline aſhes and lime water, Methods of extraction.

and then washed until the spermaceti was deprived of all foreign parts, and became perfectly white. It is purified by liquefaction, and melts at 108° of Fahrenheit.

It's singular properties.

The chemical properties of this substance appear to be very singular, since on the one side they make it resemble the fixed oil, and on the other the volatile. It melts at 35° of Reaumur, which property makes it very convenient to convert into candles, the more so, on account of it's burning with a very clear white flame, without any bad odour. In North America very large quantities of these candles are made. We are informed by Fourcroy, that a few years ago, Lepescheux established a manufactory of this kind in the Rue l'Echiquier, Fauxbourg St. Denis, at Paris; the process he makes use of consists in letting the fish oil repose in wooden casks lined with lead, and at the bottom of these casks, masses of spermaceti are precipitated, which, previously dissolved in the animal oil, separate from it gradually by a real crystallization. In proportion as this precipitation takes place, the oil becomes clear, is purified, and much more proper for lamps; when the oil is very clear, it is decanted; the spermaceti taken from the bottom, is pressed in order to separate a portion of oil which adheres to it, then melted by a gentle heat, and several times submitted to pressure and fusion, until at length it becomes white, crystalline, and of a silver colour. In this state it is moulded into different kinds of candles, which are of a splendid whiteness, and of a much more beautiful transparency and brilliancy than wax. They are also manufactured in England. Exposed to a warm air, spermaceti becomes yellow and rancid, but less easily than the other concrete fixed oils. The water in which it has been boiled, on evaporation, gives but a slight mucoso-unctuous residue.

Manufactures.

Formed into candles.

Distilled by Neumann.

Neumann appears to have been the only one of the older chemists who had chemically investigated this sub-

ftance; he found on diftillation, that it went over without leaving any refidue, and afforded not a brown, empyreumatic, ftinking oil, but a butyraceous one, which coagulated in the cold. According to Thouvenel, who feems to have appreciated in fome meafure the relations and differences of this concrete fubftance with refpect to the other folid oils, it affords no acid phlegm like fixed oils, but paffes over entirely, and without undergoing any change, into the receiver, from the time it begins to boil, leaving in the retort a carbonated trace. By repeating this operation, it lofes it's folid form, and remains fluid, without being any longer volatile. According to Macquer, it gives the fame products as butter. According to Crell, who has, by many experiments made on this fubftance, added greatly to the knowledge of it's nature and compofition, he found, that by diftilling fome good white fpermaceti on a fand bath, it acquired a greater heat to make it pafs over than what is neceffary for fat; and that he obtained a coagulated oil which appeared partly white, partly of a brownifh colour; that on repeated diftillation, it afforded a yellowifh acid, became in part more fluid, but coagulated again by degrees on repofe, by which it differed from the oil obtained from fat. The acid which by diftillation became colourlefs, united with alkalis and calcareous earth, and afforded the fame neutral falts as the febacic acid; whilft the oil, mixed with cauftic ammonia, afforded a fpecies of foap.

Thouvenel.

Macquer.

Crell.

Neumann had alleged, that the alkalis, even in a cauftic ftate, had no action on fpermaceti, and it was in vain he attempted to convert it into a foap. Lewis was of the fame opinion; and Spielmann agreed with them in it's affording no foap. Crell, however, who perceived a great fimilarity between fpermaceti and fat, thought, contrary to the opinions of the above chemifts, that it might be converted into a foap; and he fucceeded fo as to form a

Action of alkalis upon it.

ſoap, by uniting it with the vegetable alkali; it had however a much milder ſavour than the common ſort. It is found, that this ſoap becomes ſolid by degrees even to friability.

Acids. Although it has been ſaid, that acids had no effect upon it, yet the concentrated vitriolic acid diſſolves it, changes it's colour, and the ſolution is precipitated by water, like the oil of camphor. Achard likewiſe obtained a ſpermaceti ſoap by means of the vitriolic acid in it's diluted ſtate, which was decompoſed by the calx of lead, and by lime; but neither by lead nor tin, nor by diſtilled vinegar.

Sulphur. We are informed by Fourcroy, that it unites to ſulphur like the fixed oil.

Oil. Volatile and fixed oils diſſolved it by the aid of heat.

Alcohol. It is alſo diſſolved by alcohol when warm, from which it falls down on becoming cool. It was found, that one oz. 5 drachms of alcohol at 38° of the areometer, took up 6 grains of ſpermaceti, but on cooling, the whole was precipitated.

Æther. Æther diſſolves it without heat.

Such are the properties which ſpermaceti preſents to the chemiſt, as it exiſts ready formed in animals. A further inveſtigation of this ſubſtance however proves, that it is not peculiar to the cetacea claſs; and hence that it's name is now miſapplied. From the experiments, more particularly of Fourcroy, it appears, that this concrete oily body forms a genus in the animal kingdom, of which there are ſeveral ſpecies. It appears, that it is even very abundant in it, forming an oil which peculiarly belongs to it, ſince nothing of a ſimilar nature has been diſcovered amongſt vegetables. Theſe ſpecies, as Fourcroy calls them, are found to be produced either by the natural decompoſition of animal ſubſtances, by the effects of diſeaſe, or by the artificial means which chemiſtry affords.

Several ſpecies of ſpermaceti.

1ſt. The firſt ſpecies of ſpermaceti is that *peculiar concreſcible oil*, which Fourcroy found to be united in different proportions with ammonia, ſo as to form a fat ſoapy matter in the common pits of the churchyard of the Innocents, at Paris. It appears to be very different from all other known oily bodies. This concrete oil ſeparates ſpontaneouſly from the ammonia by the heat of the atmoſphere, and is found iſolated in lamellæ or yellowiſh pellucid fragments in the maſſes of ſoap expoſed to the air. It may likewiſe be ſeparated by means of acids, and it was in this manner that Fourcroy obtained it, in order to examine it's properties. When ſeparated from the fatty ſoap by acids, it always retains, more or leſs, the water either of the ſoap or acid, which being lodged between it's particles, gives it a more or leſs white colour, a granular texture, and great lightneſs; and this character is much better marked in it, than in any other ſpecies of oil hitherto known. This extreme avidity to retain water appears to belong to the primitive ſoapy ſtate of this ſubſtance; a part of it is, however, to be ſeparated either by fuſion or by expoſing it in ſmall flakes to the dry air, and if it be again melted, after this laſt experiment, it is commonly much leſs white than before, and loſes it's granular texture. The degree likewiſe of concentration of the acids employed to ſeparate it, changes it's properties. In general, every acid that is weak and diluted with water varies it's properties. Concentrated ſulphuric acid, by expoſing a portion of it's carbon, renders it blackiſh, of which hue it cannot afterwards be deprived. Strong nitric acid gives it a lemon colour, which it preſerves a long time againſt the action of the air and light. The muriatic acid leaves it unchanged, with it's white colour. The acetous acid the ſame. To procure this ſubſtance as white as poſſible, the ſoap muſt be firſt diſſolved or tempered with 12 times it's weight of hot water, and then be

1. That produced by putrefaction.

It's great avidity to retain water.

Acids vary it's properties.

Method of bleaching it.

decompofed by the acid. The concrete animal oil thus prepared, appears to be very white as long as it's flakes retain water, but in proportion as they become dry by the contact of the air, or efpecially when melted to be united in one mafs, it then becomes of a brownifh or yellowifh grey colour, and this fhade appears in almoft all the operations it is made to undergo. Fourcroy attempted to bleach it by expofure to the air, without effect, but the oxygenated muriatic acid in large quantity kept in contact with it 60 days, gave it a fufficiently beautiful white colour, which however foon diffipated on melting, and was replaced by the dirty yellow fhade.

It's properties.

With refpect to the properties of this concrete oil, it is of a granular texture, and foft to the touch when it contains water; on being preffed between the fingers, the grains feparate by giving way, but by the heat of the hand it foon becomes ductile. When dry, and deprived of water, it is of a lamellated cryftalline texture, if fuffered to grow gradually cool; if it becomes fuddenly cool it's grain is compact; in the firft cafe it refembles fpermaceti, in the fecond it is analogous to wax; hence the reafon of it's being called by both thefe names. In both ftates of cryftallization, whether granular or lamellated, when well dried, it is fonorous, breaking with a fnap like wax; the firft of thefe analogies however is much better pronounced than the fecond, and it is with fpermaceti that it has always appeared to Fourcroy to have the neareft relation. Like it, it is fmooth, greafy, and unctuous to the touch; it has neither the dry nor the hard feel of wax; it does not break as wax does, but is lamellated and fhining like fpermaceti; it is not ductile like bees wax, but crufhes like the other. It melts however at a lefs heat by 3° than fpermaceti *i. e.* at 42° of Reaum. It alfo became cool and fixed much fooner, was harder, and more fenfibly brittle. Well purified and wafhed, it has fcarcely any odour,

Compared to fpermaceti and wax.

whilſt ſpermaceti has a peculiar one. Like ſpermaceti, it is ſoluble in alcohol by means of heat; but in proportions and with appearances ſomewhat different. One ounce of alcohol between 39 and 40° of Reaumur's arcometer diſſolved at the boiling point 12 drachms of this concrete oil, whilſt the ſame quantity of alcohol at the ſame temperature, only diſſolves from 30 to 36 grains of ſpermaceti. When the alcoholic ſolution of the firſt is cool, it becomes a concrete granular maſs, in which the liquid alcohol is not ſeen. If the proportion of this laſt be increaſed ſo that the concrete oil only makes $\frac{1}{4}$ of it's weight, this matter ſeparates in grains or cryſtalline flocks, and there only remains a ſcarcely perceptible quantity of it in the cold alcohol. Spermaceti, likewiſe diſſolved in alcohol, is precipitated on cooling, but it's ſeparation takes place much ſooner, and it takes a much more regular and cryſtalline form.

Ammonia diſſolves this concrete oil with ſingular facility, and even in the cold, whilſt ſpermaceti is not at all diſſolved by it in the cold. By heat, this alkali forms with it a very frothy ſoap, the ſolution of which is clear and tranſparent, but ſpermaceti never produces this effect even when the ammonia is in exceſs. Ammonia diſſolves it.

It appears, therefore, that this concrete oil reſembles ſpermaceti in it's form more than any other oily ſubſtance, but that it differs from it in it's very tenacious colour, it's greater fuſibility, it's property of retaining water, it's being twenty-four times more ſoluble in alcohol, and in ammonia. Theſe laſt qualities, as well as it's ſonorous brittle quality; and it's often granular texture, give it a reſemblance to wax; it may therefore be called adipocerous matter. Has the name of adipocerous matter.

A concrete oil, analagous to ſpermaceti, was likewiſe extracted by Fourcroy from a piece of a human liver given him by Poulletier de la Salle; it had been ſuſpended in the open air for ten years, and was become A ſimilar ſubſtance extracted from liver.

dry, after having undergone a ſtate of putrefaction. From the experiments of Fourcroy on the liver, he found that alkali diſſolved a part of it, and formed with it a ſoap. That alcohol diſſolved a part alſo of it, which on the addition of water depoſited a *white flaky ſubſtance.* This ſubſtance, deprived of a ſmall portion that was ſoluble in water, was of a yellowiſh colour, ſoft and greaſy to the touch, like a concrete oil; water melted it under a boiling heat, but did not take away it's colour. It had then a ſlight odour like melted wax. On being caſt into a porcelain cup, it became fixed into a ſolid brittle cake, of a poliſhed ſurface, and ſnapped on breaking. It's internal texture was lamellated and manifeſtly cryſtallized. Heated alcohol completely diſſolved it, and it preſented all the properties of ſpermaceti, with this only difference, that it was not ſo dry, white, and tranſparent, but more ſoluble in alcohol than ſpermaceti. This appeared to be in a ſtate of ſoap in the liver, for water likewiſe extracted it by means of heat, and the oil was afterwards rendered concrete on cooling, but the ſmall quantity of liver prevented this chemiſt from making any further experiments. Vauquelin likewiſe extracted an oil from the liver of the ſkate, which became white as fat and as thick, and very ſimilar to wax that had been kept warm between the fingers for ſome time.

2. By diſeaſe.

2d. Having given ſome account of this concrete oily matter produced by putrefaction, the ſecond ſpecies comprehends that produced by diſeaſe, as in the biliary calculi; for the chemical inveſtigation of which we are likewiſe indebted particularly to Fourcroy. It is obſerved, on treating on biliary calculi, that Poulletier, on diſſolving ſome in alcohol, found that it depoſited a lamellated brilliant ſubſtance, reſembling boracic acid. It is this matter that Fourcroy found to have a great analogy to ſpermaceti. Having diſſolved part of ſome of theſe cal-

In biliary calculi.

culi in alcohol by means of heat, on cooling, he found the solution deposited a great quantity of white brilliant crystals, which were the concrete oil to be examined. Having exposed them to heat, they soon melted, and formed a yellow, unctuous, roapy liquor, very small in bulk to what they were before; this liquor exhaled an odour like wax. On continuing the heat, a penetrating white vapour arose like that from a roasted oil; on cooling, it became a concrete, brownish, dry mass; brittle, and in it's fracture presented a laminated, and polished structure, which announced a crystallization, or at least a remarkable tendency to it. These phenomena succeed each other very rapidly, and by a very feeble heat. If this crystalline matter be heated suddenly, and strongly, it becomes entirely converted into vapours, and only leaves a brownish yellow spot in the silver spoon in which it is melted. Method of obtaining it.

Water has no effect upon it; in boiling water it melts and rises to the top like an oil, and becomes concrete again, on cooling. Action of reagents upon it.

Liquid, caustic, fixed alcalis, dissolve it in the cold, and form with it soaps.

The nitric acid dissolves it without heat or effervescence, forming a solution that resembles *oil of camphor*. It is decomposed by water, and flakes and lamellæ are separated in their former state.

Alcohol when hot, dissolves a large quantity; according to Poulletier, one oz. 5 drs. and 12 grs. of alcohol dissolved at 60° of Reaum. 50 grs. of this white crystalline matter; but the greater part separates on cooling. It was these last results that convinced Fourcroy of the striking analogy between this substance and spermaceti. Calculi of the gall bladder are even found in some cases to be totally formed of this concrete oily matter; for which see article *biliary calculi*. Forms biliary calculi.

3. By nitrous acid.

3. Befides the converfion of animal fubftances into a concrete oily matter, refembling fpermaceti, by means of natural decompofition, and that brought about by difeafe, it has been found by Gibbs, that the fame converfion takes place by the nitrous acid; and the concrete oil obtained, has precifely the fame characters as that obtained by water, *vide* putrefaction. That which he obtained from human mufcle was melted, and the thermometer rofe, when plunged into it, to 160°; it congealed at 112°, and became folid at 110°; whilft fpermaceti of the fhops, under the fame circumftances, when fufed, forced the thermometer to 170°; at 117° a pellicle was formed on the fubftance, and it became perfectly folid at 114°.

Compared with fpermaceti.

A piece being diffolved in boiling fpirit of wine, the mixture let fall a great quantity of this waxy matter in the form of beautiful flakes; large cryftals could not be procured, but the flakes affumed a cryftalline appearance.

Diftilled.

A fmall quantity was put into a copper retort, and placed on a common fire: at firft, there came over a limpid fluid like water, without much fmell; by a ftronger heat, an oily fluid arofe which foon coagulated; it was of a firmer confiftence than when put in, and coloured of a beautiful green by the copper; which laft circumftance, he thinks, proves that it contained no ammonia.

Some of this waxy matter was put with fome finely levigated charcoal into an earthern retort, a ftrong heat was applied, when a fmall quantity of an oily fluid came over, which concreted on cooling; after which came over a prodigious quantity of thick white vapours, very fuffocating and offenfive.

The nitrous acid converts flefh into this fubftance in three or four days, and he found that when this febaceous matter was produced from the human fubject, it

aſſumes a very beautiful and regular cryſtalline appearance, whilſt that from quadrupeds ſeems not diſpoſed to cryſtallize.

After the converſion by water, this ſubſtance has a diſagreeable odour; and although the nitrous acid takes off the greateſt part of the fetor, it gives it a yellow colour and the ſmell of the acid, which mere waſhing, and the addition of alcalis, will not entirely remove. In order to whiten this ſubſtance, the following proceſs will make it very pure and beautiful, but not ſo white as the ſpermaceti of the ſhops. It is broken into ſmall pieces, and expoſed for ſome time to the combined actions of the ſun and air, by which it loſes a great deal of it's ſmell, and acquires a firm conſiſtence. It is then powdered, and weak nitrous acid poured upon it; in an hour a froth is formed, and the acid is decanted, and the ſubſtance repeatedly waſhed, then melted in hot water, and when cool, is concreted, and is of a beautiful ſtraw colour, and has the agreeable ſmell of the beſt ſpermaceti. This might be made uſe of in the arts. Method of bleaching it.

It may be proper to obſerve here, that previous to the experiments of Gibbs, Berthollet had already uſed the ſame method of ſeparating animal oil from the different parts of animals. He extracted the nitrous acid from theſe ſubſtances, but not in leſs quantity than is ſufficient to obtain the oxalic acid, which is from ſeven to eight parts, and this afforded him a fat matter. Of theſe ſubſtances, gelatin gave him the leaſt fat; ſilk, wool, and hair, the moſt. A ſmall quantity went over with the acid, coloured it yellow, and gave it the ſmell of animal oil. This fatty matter was not, however, in a concrete ſtate.

This converſion of animal ſubſtances into this concrete fatty matter is ſaid to ariſe by depriving them of their azot; but with reſpect to the utility of the knowledge of The converſion accounted for.

theſe changes, the matter may be either converted into ſoap, or manufactured into candles, as it burns with a fine flame. By comparing, therefore, ſpermaceti with the concrete oil ſeparated from the ſoapy matter of inhumed bodies, with that ſeparated from the dried liver, and with that which exiſts in abundance in biliary calculi, Fourcroy has, it appears, found differences in the forms, dryneſs, fuſibility, and ſolubility in alcohol and in æther, which are very remarkable, but which have not prevented him from making the reſemblance, and from conſidering them as matters of the ſame genus, differing only in theſe ſpecific characters; whether theſe, however, are ſpecific differences, or only varieties, further obſervations muſt prove. It remains therefore to determine,

A further inveſtigation required.

1ſt. The real compoſition of theſe concreſcible, cryſtallizable oils, which are neither butters, ſuets, nor waxes; which do not exiſt in vegetable ſubſtances according to their preſent analyſis, and which differ from the concrete oils of plants, as the liquid oils of animals differ from the liquid oils of vegetables:

2d. The diverſified compoſition of theſe ſpecies which conſtitute this newly diſtinguiſhed genus of cryſtallizable animal oils, their relations between them and the liquid animal oils, and their formation. Theſe diſcoveries appear now within the reach of chemiſtry, and no doubt will be effected by thoſe who undertake the labours they require. Fourcroy has already begun the inveſtigation, by treating the oil extracted from bile, (which has been falſely looked upon as a reſin) by the oxygenated muriatic acid, and he has converted it into a dry and concrete ſubſtance, analogous to ſpermaceti. The ſlow decompoſition of ſolid animal ſubſtances, inhumed in a maſs, prove alſo by the converſion of the muſcles and ligaments into fat, that the fibrous, albuminous, and gelatinous

matter may paſs into a concreſcible oil. It will likewiſe not be forgot, in the analyſis of ſpermaceti, and the animal concreſcible oils that reſemble it, to inveſtigate the cauſe of it's being ſo abundantly formed in the cetaceous claſs, and the uſe of it in the cavities of the cranium, and in the ſpinal marrow, and the reaſon why it is found in greater quantities in animals that breathe little than in thoſe which reſpire much, *i. e.* in warm blooded animals, and why in theſe laſt this concrete oil appears only to reſide in the liver and the bile, whilſt it exiſts ſo univerſally in the animals with cold blood.

Fat.—This is a fixed oily ſecretion, which in point of conſiſtence appears to hold the medium rank between ſpermaceti and the fluid oils; it is not ſo concrete as the one, and more ſo than the other. It is formed at the extremities of the arteries, according to the beſt authors, and at the greateſt poſſible diſtance from the centre of muſcular motion, and of animal heat, by which means it preſents a ſpecies of reſervoir where a great quantity of hydrogen, not evacuated by the lungs, becomes fixed. Fat.

In young animals it is of a white colour, and has a mild inſipid ſavour, but in adults it very often tends to a yellow colour, and as age advances it's colour becomes deeper and it's ſavour ſtronger.

To obtain it pure, and fit for chemical experiments, it muſt be cut into ſmall pieces; the membranes and ſmall veſſels are then ſeparated; it is waſhed in a large proportion of diſtilled water, to deprive it of all it's gelatinous part, kneaded by the hand and the water, renewed until it becomes inſipid and colourleſs; the fat is then to be melted by a moderate heat in a glaſs or new earthen veſſel, together with a little water, which when evaporated, the boiling noiſe of the fat in fuſion ceaſes. It is then to be poured while hot into another veſſel, where it fixes on cooling and becomes ſolid. The uſe of the water added to the How purified.

fat, is to prevent it's roafting and becoming black; it likewife forms a fpecies of water bath, rendering the heat more equal; but it is neceffary not to let any remain, as it would haften it's rancidity. This is known by dropping a little of it on fome red hot coals, where it burns without crackling, if it retains no humidity.

Fat when thus purified, is white, nearly inodorous, or has rather a weak aroma that is peculiar to it; it's favour is mild, and oily, and in this ftate it approaches very much to the fat vegetable oils, as thofe of olives, benzoin, &c. which have no refinous or gummy properties, and are not ficcative.

Examined by the microfcope.

Fat when examined by the microfcope, is faid to exhibit a number of yellowifh veficles, formed of a very thin and tranfparent pellicle containing an oily fluid. Thefe veficles differ in fize in various animals; according to Wolf, the fat of the pullet is contained in fmaller veficles than thofe of any other animal, whilft the veficles of the goofe are larger, and arranged with more regularity. The next in order are the human; but the moft confiderable are thofe of the hog. It's only refervoir, according to Scopoli, is the cellular membrane.

It's analyfis.

Neumann.

With refpect to the chemical analyfis of fats, Neumann, from his diftillation of the fat of the goofe, the pig, the fheep, and the ox, from which he obtained an empyreumatic liquor, brown oil, and charcoal; and from his other analyfes, concludes, there is but little difference in fats; that the fat of the ox only appeared to contain a little more earthy matter. He looks upon them as a phyfical mixture of oily, gelatinous and aqueous parts, with a little earth, and fome faline parts interpofed.

It is fcarcely neceffary to obferve, how far the experiments and obfervations of this chemift are diftant from the prefent precifion of chemical operations. He takes

no notice of the lofs of one part into it's aeriform elements, and decides without any examination, that the coaly refiduum, or the caput mortuum, as he calls it, is an earth; whilft it is now well known, that the carbons of animals which fo powerfully refift incineration, contain the phofphoric acid. It is lefs aftonifhing that he takes no notice of the acid, for Macquer has confeffed, that although forewarned of the faid production from diftillation of blood, by the obfervations of Homberg, he was on the point of concluding that this chemift was deceived, becaufe the prefence of the oil prevents this acid from acting on blue paper, and the part touched only became red on beginning to dry; and this is moft probably the reafon why fo many chemifts have erred refpecting the real nature of one of the products of the diftillation of animal fubftances as well as vegetable. Macquer.

Hoffmann was of opinion, that the faline principle of fat and animal oils was purely alkaline, in which they differed from vegetable oils; and advanced as a proof, that thefe laft occafioned a green ruft in copper veffels, whilft fat on the contrary, when kept a long time in the fame, gave them a beautiful blue colour; an effect according to this author that could only be produced by an alkaline principle: this argument however is now proved to be falfe, as it is well known that this colour only depends on the more or lefs oxydation of the metallic calx. Hoffmann.

Vogel had a much better knowledge of the empyreumatic oil extracted from fat by the fire, and acknowledged the prefence of an acid faline principle; but the experiments of later chemifts, as Segner and Crell, leave no longer any doubt on the fubject. Vogel.

According to Plenck, fat is nine times lighter than diftilled water. It requires for it's fluidity a greater heat than olive oil, which is fluid at 40° of Fahrenheit's thermometer, and a lefs heat than yellow wax, which melts Plenck.

at 140°. It contains no parts fo volatile as to be forced over at a boiling heat, and it only inflames at a temperature that converts it into vapour.

Diftillation. If fat be diftilled by expofing it in a retort to a greater heat than that of boiling water, there firft comes over an acid water, and a fmall quantity of oil, which remains in a fluid ftate; on continuing the heat this acid becomes ftronger (*vide* febacic acid), and the oil always lefs fluid; but the degree of heat muft be ftrong enough to prevent the coagulation of the oil, fo that one drop may immediately fucceed another.

If the oil, which has a very naufeous fmell, be fubmitted to a fecond diftillation, it becomes more fluid, and at each rectification an acid fpirit is feparated, and a coaly refiduum left behind. It's fmell becomes more penetrating, and by repeating the diftillations, it may be brought to have the volatility of effential or ethereal oils, and to evaporate at the heat of boiling water. By repeated abftraction and edulcoration by water, it is fo deprived of it's acid, that Crell obtained it fo pure as to be volatile at a lefs than boiling heat. Hence it appears, the fat derives it's confiftence, and alfo it's fixednefs, from the acid, from which it can only be feparated by repeated diftillation.

According to Hildebrandt, if the fharp vapour which arifes on the acid coming over catch flame, it produces a good deal of fmoke and foot. By the dry diftillation it affords hydrogen and carbonic acid gafes, and the oil which before was yellowifh becomes dark, and at laft of the confiftence of pitch. When the iron is red hot there

Crell. remains a little coal of difficult incineration. Crell having by an exceffive and long continued heat incinerated this coal, found the afhes to be of a lightifh red colour, which when lixiviated with diftilled water and evaporated, gave a falt of no determined fhape or favour, did not

deliquefce in the open air, but diffolved in water, and a little vitriolic acid added depofited gypfum. This earth however left behind it it's conftituent part, an acid, which after evaporation, appeared a white, dry, acid falt, that melted before the blowpipe into a tranfparent globule; and mixed with foot, and expofed to diftillation by a ftrong heat, emitted a phofphorefcent light, confequently it was the phofphoric acid. Befides the difcovery of this acid in the afhes, Crell found they contained calcareous earth in a free ftate. In diftilling fat, great care muft be taken to avoid the fharp, penetrating and volatile acid vapours that arife, otherwife they irritate and inflame the eyes, the throat, and the lungs; they not only force tears, but excite a cough as bad as fulphureous vapours.

It is infoluble in water. Action of water.

Acids form foaps with fat, as with the fat vegetable oils. Achard formed foaps of this kind with the vitriolic acid and the oil of the yolk of the egg, as well as train oil, which he found to be decompofed not only by alkalis, but by acids; according however to Leonhardi, diftilled vinegar does not effect a decompofition. By the nitrous acid, with a certain degree of heat to produce a decompofition of fat, the acid of fugar is obtained. Acids.

Alkalis, particularly when cauftic, as well as cauftic earths, likewife form foaps with fat, which are decompofed by acids. Alkalis.

Alcohol has no folvent power on fat, except in it's rancid ftate; it then diffolves the rancid part. Alcohol.

Fat, like oils, diffolves fulphur and phofphorus; it has the fame power on metallic calces, particularly thofe of iron and lead; it attracts quickfilver by means of trituration; unites with the regulus of arfenic by ebullition, and enters into the compofition of plafters; it foon rufts copper, which proves the danger of letting it remain in veffels of that metal; and Fourcroy is of opinion that Solvent power of fat.

it even acts on the glafs of lead with which pots are glazed.

Extracts and mucilages render fat foluble in water.

It unites with oils in all proportions, and increafes their confiftence.

Rancidity.

Fat in it's natural ftate has it's acid fo intimately united to it's oily part, that none of it's properties are to be difcovered; hence arifes the mildnefs of this oily fubftance. But it has been before obferved, that when by a fufficient degree of heat a decompofition extricates this acid, it's properties are entirely changed, it becomes fharp and irritating. The fame thing happens when fat has been expofed for fome time to the atmofphere; a partial decompofition takes place, a little of the acid becomes extricated, the colour becomes brownifh or yellowifh, and the tafte and fmell are fharpifh and difagreeable; and this ftate is called *rancidity*. It is likewife found different in it's chemical properties; for alcohol, that in it's mild ftate had no effect upon it, now diffolves the rancid part, leaving the reft untouched. De Machy, a Parifian chemift, has, therefore, very properly obferved, that by means of wafhing in alcohol fat may be deprived of all it's rancid part, whilft it leaves the found part. Pœrner propofes, as a more economical plan, to deprive it of this rancidity by mixing and boiling it with frefh fpring water, to fkim it, and repeat the operation. Macquer propofes to add a little calcareous earth or alcali to the water, the better to abforb the acid of the rancidity, and afterward, by edulcoration with a large quantity of pure water, carry off all the faline or foapy matter that may have been formed.

Changes the properties of fat.

Becomes foluble in alcohol.

Various methods to deprive it of its rancidity, and opinions on the caufe.

Thefe obfervations appear to Morveau to admit of no doubt, but that the acid developed puts the oil, no longer a perfect fat, into a ftate of foap, otherwife it could not be extracted by water alone, whilft the properties of

the unchanged fat would to a certain point be altered. Fourcroy is of opinion that this change in fat arifes from the fermentation of a peculiar animal mucilage, of which fat always retains a certain portion intimately combined with it, and that the rancidity proceeds from the extrication of the fixed air. On this fuppofition, the addition of fixed air muft correct the rancidity; and Sieffert informs us this was done by mixing fweet fruits or honey with rancid oils, fo as to occafion a fermentation, and a production of fixed air, which reftores to them their gas. Rozier and Œttinger have confirmed this obfervation, and even have corrected, and meliorated fat, and rendered it fweeter and firmer by putting apples, or other fruits, into the pot in which it was melted. Rozier even recommends a fpunge to be dipped in a mixture of alum and chalk, and to be placed at the bottom of the oil veffel, by which means the acid of the alum will extricate the fixed air from the chalk, which will mix with the oil. It appears that Morveau even is not far from admitting a fort of fermentation in fat, *i. e.* a more or lefs fenfible motion determined by the affinities of the air, and the heat, producing new combinations: in fhort, he thinks it very probable that oils change in the manner acids do; that a new portion of the acidifying principle unites to them in the fame way, which laft is proved from the experiments of Haffe; and Scheele precifely fays, that the air is diminifhed by oils which become refinous: Morveau, however, confeffes that much is wanting to conciliate this theory with all the phenomena.

From fixed air.

1ft. It fuppofes an animalization in fat, which is oppofed by facts. 2d. Recent fat, diftilled in clofed veffels, undergoes a change perfectly analagous; fome developped acid is alfo formed: hence it muft be acknowledged, that the acidifying principle preexifted in the fat; that it was there in fufficient quantity inftantly to produce

that change which the accefs of air produces in a length of time; or it muft be faid with the celebrated Scheele, that the vital air may proceed here from the decompofition of the matter of heat. Fat is likewife foluble in alcohol, after it has been precipitated from foap by means of acids.

It would be of ufe to examine what influence the fweet faccharine matter, which Scheele found in oils, has upon their rancidity. It is faid, that if fat or butter be boiled with half the quantity of litharge in water, to the confiftence of falve, the water becomes fweet, and by evaporation is converted into a fyrup. This contains nothing if the oil be mild, but if rancid, a little of the litharge, which is precipitated from it by vitriolic acid. By a ftronger heat, an inflammable vapour arifes, and it requires, to be forced over, the boiling heat of oil of vitriol; it then comes over in part undecompofed, having it's fweet tafte, whilft the other part is empyreumatic, and is converted into a brown oil, with a fmell of alcohol; a light fpungy coal remains, containing no calx of lead. By repeated diftillation, it appears to undergo a further decompofition, and with a little fpirit of tartar, to become fharp and bitter. This fweet fluid does not cryftallize, nor ferment when mixed with water and placed in warmth. It mixes with the fharp tincture of tartar without attracting and falling down with it, as honey does. By repeated abftraction of nitrous acid, it is at laft changed into acid of fugar, and appears, according to this chemift, to contain more phlogifton than even fugar or honey.

Sebacic acid.

The acid of fat which caufes it's rancidity, is likewife the caufe of it's fixity; hence the febaceous fubftances are like particular oils that owe their confiftence and fixity to the fame caufe. As a proof of this, according to Pœrner, if the oil of almonds be digefted for a little time with a

ſmall quantity of nitrous acid, a ſubſtance reſembling fat will be obtained.

That the different conſiſtence of fats is owing to the proportions of the ſebacic acid with the oily parts is alſo proved, from the compariſon of the quantity of theſe products in Crell's experiments on human fat, and the ſuet of the ox. In ſhort, it is to the intimate union of different proportions of this acid with the oil, that the greater or leſs fixity of them is to be attributed; and that, in proportion as this principle is taken away, they become fluid and volatile, reſembling eſſential oils, is evident on diſtillation, where the more the fats are deprived of it, the more fluid and volatile they become, and riſe at the boiling point. It appears however that this acid is more intimately united in animal oils than in any other, as they are much longer in becoming rancid; and ſubmitted to repeated diſtillations, very little acid is extracted at each proceſs, hence they are the moſt difficultly made fluid and volatile.

The conſiſtence of fat owing to the laſt acid.

It is the opinion of Morveau that this ſebacic acid exiſts perfectly formed in fats previous to diſtillation, ſince theſe ſubſtances expoſed to the fire in cloſe veſſels give their vital acidifying air in a ſtate of mephitic gas; beſides, according to this chemiſt, the ſtate of the carbonaceous reſidue, which reſembles plumbago, from it's difficult incineration, announces a conſiderable quantity of vital air fixed in this reſidue, and converted into mephitic acid. In ſhort, it appears (article ſebacic acid) that the ſeparation of the acid, and of the oily portion, may be effected by the moiſt way, without the aid of heat, a demonſtrative proof of it's being already formed. The manner, however, in which theſe two parts are united, ſince they cannot be recompoſed, ſhows it is not a ſimple combination, but one which further experiments muſt explain.

It exiſts perfectly formed in fat.

Gren and Ricchen inform us, that they have at length perfectly decompofed fat by repeated infufion and digeftion, with moderately ftrong nitric acid, into oxalic acid and vinegar.

Various kinds of it.

The various kinds of animal fat that have undergone any chemical inveftigation, are *human fat*, *fuet*, *marrow*, *lard*, and *butter*.

Human fat.

Human fat. Rhades was the firft who examined human fat, but very little can be collected from his experiments; it is to Segner and Crell that we are indebted for what little is known of it, as well as of the greater part of other fats. It's fpecific gravity is to water as 0,903 to 1000, and it is fluid at 84° of Fahrenheit.

Experiment of Segner;

On diftillation, this fat afforded nothing at 450° of Fahrenheit, and very little at 550°; it was only at 600° that there paffed over 100 drops of phlegm, and a great proportion of oil: from four ounces, fix drachms of a very thick oil remained in the retort. This phlegm appeared to give the fyrup of violets a reddifh tinge; the fmell was ftrong, and fo infupportable that it's nature could not be determined; it had a very empyreumatic, fharp, fomewhat acid favour. The remaining oil was of the confiftence of honey, of a fweetifh tafte, and a flight empyreumatic odour. The phlegm effervefced with the folution of potafh; on faturation, it had a faline tafte, and gave on evaporation a thickifh, yellowifh liquor. On examining fome friable, irregular parts, they appeared to have a cryftallized form. This dried mafs expofed to the air returned to a faline, fharp, and bitter liquor, not alkaline.

of Crell.

According to the experiments of Crell, in a memoir exprefsly written on the conftituent parts of this fat, it appears, that 28 oz. of it, being previoufly melted and filtered, when diftilled on the fand bath, melted at 155° of Reaumur's thermometer, and there came over a little infipid phlegm. The diftillation then ftopped, although

the heat had been increafed 45°, but being augmented beyond 220°, the mafs began to fwell exceedingly, fo as even to rife into the neck of the retort, which is not the cafe with *ox fat*. At the fame time there paffed over a liquor accompanied evidently with vapours, which when collected in the receiver appeared to be of two kinds; that at the top was a brown red oil, the colour of which became by degrees deeper, and beneath this was a phlegm of a golden colour. At the bottom of the receiver there was a fixed oil refembling that from wax: the heat being increafed until nothing more came over, the operation lafted 21 hours. At the mouth of the receiver, a very penetrating odour was perceived, although lefs lively than that from *ox fat*. The liquors being feparated, there were found $2\frac{1}{2}$ oz. of black oil, and 1 oz. 7 drachms of a yellow acid phlegm. There remained in the retort a fhining, friable coal, weighing 1 oz. 2 drachms, 2 fcruples. The fixed oil melted, and diftilled again by a heat of 200°, afforded 9 oz. of oil lefs coloured than the firft, 1 oz. of yellow acid, and more fixed oil. This oil being twice again diftilled, this chemift received by the fame heat, the firft time 7 oz., 6 drachms of a reddifh yellow oil, and 3 drachms 30 grains of acid. The laft time, the heat being carried to the moft violent degree, there were found in the receiver 1 oz. 3 drachms, 40 grains of brown oil, and only one drachm of acid. The carbonaceous refidua were of the fame nature as the laft, and weighed one ounce 7 drachms. Thus 28 oz. of human fat, on being decompofed by diftillation afforded,

	oz.	dr.	gr.
Of fluid oil	20	5	40
acid phlegm	3	3	30
charcoal	3	1	40
Loft during the procefs	0	5	10
Total ..	28	0	0

To ſeparate the acid that might adhere to the oil, this chemiſt agitated it at ſeveral times in water, and ſeparated it by a ſiphon; the waters being collected were ſaturated with 1 drachm 7 grains of potaſh, and as it requires $6\frac{1}{2}$ drachms of this alkali to ſaturate 30 grains of the acid, he concluded, that theſe waters had ſtill given $14\frac{1}{2}$ drachms of acid.

The brown oil rediſtilled by a gentle heat afforded a volatile, clear oil, of an aromatic ſavour; on increaſing the heat it became yellow, and at laſt reddiſh. There remained 3 oz. 30 grains of charcoal.

Two ounces of this coaly reſiduum were with great trouble incinerated. The aſhes weighed 5 drachms 30 grains. Boiling diſtilled water only extracted from them 4 grains of an inſipid ſalt, and a little calcareous earth was precipitated by the addition of vitriolic acid. The nitrous acid on digeſtion deprived the aſhes of their red colour, but the vitriolic only precipitated a little ſelenite. The liquor exſiccated, and the reſiduum calcined, became red, and amounted to 6 grains. This chemiſt regards this fixed ſalt as the ſame as what he got from the aſhes of *ſuet*, *i. e.* the phoſphoric acid. Of the 4 drachms of remaining aſhes, the vitriolic acid on diſtillation took up 40 grains of aluminous earth, and the ſurplus, mixed with an equal quantity of fixed alkali, ran into a perfect glaſs.

It remains to be proved, whether the redneſs was owing to the preſence of iron, and whether the argill did not come from the veſſel. With reſpect to the glaſs, it is well known that the vitrification of bones depends on the phoſphoric ſalt.

Suet. *Suet.*—Ox ſuet, ſubmitted to diſtillation in a ſand bath, melts at from 104° to 116° of Fahrenheit; it afforded a good deal of oil, and but little phlegm: the odour ariſing from theſe products affects the head: acids had no effect

on them: they formed ſoaps on agitation with a ſolution of potaſh. The reddiſh phlegm had an acid taſte, effervefced with an alkali, yet it did not redden the ſyrup of violets, but communicated to it rather a browniſh tinge, which aroſe from the oily parts.

Diſtilled with unlixiviated aſhes it afforded no volatile alkali. The oil that came over was nearly black, ariſing from the great heat neceſſary to break the ſoapy union. The phlegm reſembled ſpirit of tartar, did not effervefce with an alkali, and changed the ſyrup of violets green.

With potaſh ſuet likewiſe afforded a blackiſh oil; the phlegm had an alkaline ſavour; it effervefced with the nitrous acid; the alkali by means of the oil had reached the neck of the retort.

From two pounds of ox ſuet Crell obtained 14 oz. 1 drachm of fluid oil, 7 oz. 2 ſcruples of acid, and there remained of coal 10 oz. 6 drachms and one ſcruple.

Stag ſuet requires the ſame heat for fuſion as that of the ox, and that of the ſheep melts at 124°.

Marrow.—The marrow of the ox on diſtillation afforded ſimilar products to ſuet, except that there paſſed at firſt into the receiver a white ſuet reſembling the butter of wax. It afforded an inſipid water, much oil, the greater part of which became fixed again, and very little phlegm; alſo an acid was obtained. Marrow.

Lard.—Hog's lard on diſtillation afforded a brown fluid oil, but ſcarcely any phlegm; a few grains of black matter remained in the retort. It melts at between 99° and 100° of Fahrenheit. The oil weighed nearly as much as the lard employed, had a weak empyreumatic odour, gave no ſigns of ammonia; the taſte ſeemed to indicate an acid, but it ſoon became bitter. This oil gave the ſyrup of violets an obſcure colour tending to a green. Lard.

Butter.—When this inflammable part of milk is freed from all it's ſerous and caſeous matter, it is either of a Butter; it's natural colour.

white or yellowifh colour, according to the ferum and the food and temperament of the animal; the more the plants are fucculent and aromatic, as happen in fummer, the more the butter will be coloured; and during the winter, when only hay or ftraw and bran are to be procured, the yellow colour difappears by degrees, and they afford only a dead white butter. This effect however does not take place in all animals, for the cow, the goat, the afs, and the mare, although nourifhed in the fame paftures on the fame nourifhment, afford different coloured butters; the cow gives a yellow one, that of the goat and afs is much paler, whilft the butter of the mare is always white.

Artificially coloured. Butter is artificially coloured by many fubftances, and as it is one of the beft folvents for extracting the refinous colouring matters contained in certain plants, they are often made ufe of in the dairy. Thus, by beating the cream with the root of the orcanet, a colour is procured from the lighteft fhade to the deepeft red, which cannot afterward be feparated by water. This property of butter to load itfelf with the colouring matter on feparating from the cream, Parmentier expected might extend to the green parts of plants; this was not however the cafe, but it received the aromatic parts. He found that when cream is beaten with a refinous colouring matter, it is the butter that is coloured, but when an extractive matter is employed, the buttermilk or ferous part only remains coloured.

Savour. Butter, when frefh, has a very pleafant and peculiar mild tafte, although it's tafte, as well as it's colour, depends on the food of the animal. If, for inftance, it has been previoufly fed on turnips, or on grafs with which garlick grows, or on cabbage, or various herbs the effential oil of which is ftrong and penetrating, the butter partakes of their favour.

Aroma. It is nearly void of fmell.

It is more or lefs of a foft folid confiftence; it is very folid from the milk of the goat and cow, and foft from that of the fheep; whilft from the milk of the afs, the mare, and the human female, it is nearly in the ftate of cream, more particularly that of the laft. Confiftence.

When expofed to a moderate heat it melts and becomes tranfparent. According to Erxleben this degree is 84° of Fahrenheit; the fufion is perfect at 88°, and it remains fomewhat fluid even at 74°; it becomes folid again in the cold, but it is then fomewhat granulated; in this ftate it keeps a long time without becoming rancid, but it has not that agreeable rich flavour it had before. Expofed to heat.

On diftillation it affords a little infipid water, the febacic acid, a yellowifh fetid oil, called the oil of butter, and according to Scopoli, hydrogen gas. There remains about ½ oz of coal from one pound of butter. Several modern chemifts are of opinion, that it is from the oxygen of the atmofphere that the formation of the acid arifes. In the firft diftillation, however, this is unneceffary, becaufe the quantity of oxygen in the butter is fufficient; but in fucceffive diftillations, Fourcroy found the external air neceffary to convert all it's principles into an acid; hence in a large apparatus a great deal is formed; on the contrary, in a fmall retort butter paffes into the receiver, almoft without alteration. Butter forms with potafh a foap lightly folid, of a yellow colour and agreeable odour, eafily foluble in water, and which perfectly cleanfes all kinds of ftuffs. Forms foap with potafh.

In a warmifh temperature, or in more or lefs time, the febacic acid is fpontaneoufly feparated from butter; it then acquires an acrid and rancid fmell and tafte, which is partly corrected by wafhing it in alcohol to take away the acid. Hence it appears that butter is very little different in it's chemical properties from the fat oils of the vegetable kingdom.

It's particles give the yellow colour to milk. Vide *milk*.

Train oil.

Oil of fiſh, or thran, or train oil. This is fluid, about the conſiſtence of ſyrup, and is very common in various manufactures, where it is employed for various uſes. Few experiments have been made upon this oil. Dr. Prieſtley, has, however, informed us of ſome curious circumſtances reſpecting it. They were in conſequence of an attempt to confine the nitrous acid vapour by means of animal oils, and the oil he uſed was *whale oil*. He found that on mixing nitrous vapour and nitrous air with this oil it became hot, and was changed to a green colour; on cooling, it became red and coagulated; and when mixed with other oil, it ſeparated from it and ſunk to the bottom exactly like the ice of oil, and continued there without mixing with the reſt of the oil. On making a quantity of alcaline air paſs through the oil, ſaturated with nitrous vapour in order to mix it with ſome air that had iſſued from it, the oil, from be ng red, became almoſt quite black.

Dr. Prieſtley's experiments upon it.

With nitrous acid vapour.

A part of the whale oil that had been uſed in his firſt attempts to confine the nitrous acid vapour, of a dark red colour, and coagulated, being melted and put into another phial, and then impregnated again with freſh nitrous vapour, became of a deep blue colour. In cooling, it became of a dirty green, then inclined to a yellow, became a lit le fluid, and continued ſo.

A quantity of *freſh whale oil* became blue by this mode of impregnation. On cooling, the upper part became ſtiff, and aſſumed a light orange colour, while the lower part ſtill continued blue and fluid; but it became at length of a deep orange, and was perfectly coagulated throughout. T e oil, about two months after impregnation, on being melted, retained the ſame colour and it's peculiar ſmell, though mixed with that of the ſpirit of nitre.

From his experiment upon this oil and others, he found that all oils readily decompofe nitrous air as well as imbibe nitrous vapour; that the effects of this impregnation is, that they are in general coagulated and become of a red colour; and that in all cafes in which nitrous air is decompofed, Dr. Prieftley found it is reduced to the ftate of phlogifticated air. It is in this way that he explains the phenomena which took place in his experiments on the whale oil above mentioned. But the phenomena attending the proceffes, from the firft to the laft ftage of impregnation, are very various and remarkable.

The firft exprefs mention of foaps occurs in Pliny, and Galen; the former declares it to be an invention of the Gauls, though he prefers the German to the Gallic foaps: Pliny fays that foap was made of tallow and afhes, that the beft was made of goats' tallow and the afhes of the beech tree, and that there were two kinds of it, hard and foft. The author of a work (De Simplicibus Mēdicaminibus) on fimple medicines, which is afcribed to Galen, but which Beckmann is of opinion was not written by that author, and of which a Latin tranflation only has been printed, fpeaks of foap being made by a mixture of ox, goat's, or fheep's tallow, and a lye of afhes ftrengthened with quicklime. He fays, the German foap was the pureft, the fatteft, and the beft, and that the Gallic was next in quality.

Animal foaps.

Their antiquity.

This account correfponds more exactly with the procefs ufed in Germany at prefent, while the French ufe mineral alcali, and inftead of tallow employ oil, which appears to be a later invention. Pliny in his defcription does not fpeak of quicklime; but as he mentions a mixture of goats' tallow and quicklime a little before, it is probable that the lye of the latter was then known at Rome. Gallic and German foap are often mentioned by later writers as well as by the Arabians, fometimes on ac-

count of their external ufe as a medicine, and fometimes from their wafhing qualities.

It has already been obferved, that animal oils form foaps with cauftic alcalis; it is only however in thefe countries where the climate will not produce the olive, that they are made ufe of in the fabrication of foap. Olive oil forms a foap far fuperior to animal oils; but they in their turn are preferable to the expreffed oils of vegetable feeds. Some experiments on the fabrication of animal foaps have been made by Darcey, Lelievre, and Pelletier; the method they ufed, was to render the foda cauftic by means of lime; they then boiled the alcali and oil together until the foapy matter began to feparate, marine falt was then added to finifh the feparation.

Experiments on the making of foaps by Darcey, &c.

They took eight pounds of fuet, which, by uniting with cauftic foda, compofed a foap that weighed eight pounds fourteen ounces; it was of a good quality, of a white colour, preferved however a little odour of the fuet; kept for three months and a half in a dry place, it had loft three pounds fourteen ounces, but had acquired a great degree of folidity.

By the union of three pounds of lard with cauftic foda, a foap was formed that weighed eight ounces and half; it was very white and folid, and it's odour was not difagreeable. On expofure to the air for three months, it only weighed four pounds fourteen ounces. It was then very dry.

Three pounds of rancid falt butter, after being deprived of it's falt by water, formed a foap that weighed eleven pounds; it was very white, but retained a little of it's rancid odour. Expofed in a dry place it loft much of it's weight.

The fame quantity of what is called horfe oil (huile de cheval) at Paris, when united with foda, formed a foap that weighed feven pounds; it was white, and of a

good confiftence. On expofure to the air for two months it loft two pounds. It had no difagreeable odour, and acquired great folidity.

A fimilar quantity of whale oil united with foda weighed five pounds; it was of a dirty grey colour, and had a difagreeable odour. On being kept two months in a dry place it loft eight ounces of it's weight; but it had acquired fo deep a brown colour externally, as to appear red. It was of pretty firm confiftence, but not dry like the olive foap. Soaps made of fifh oil, and of the oil of the cod fifh, greatly refembled it.

Henry made fome experiments to try the action of metallic oxyds and earths upon oils, in low degrees of heat. He digefted 2 ounces of fpermaceti oil with one drachm of white arfenic, in a heat of 180° of Fahrenheit, for fix hours, and let it ftand till next morning. The oil was then perfectly clear and colourlefs, and heavier than before. A great part of the arfenic, however, remained undiffolved at the bottom of the digefting veffel. Thick train oil was digefted with one drachm and a half of white arfenic. No great alteration was obferved in the colour; but it was clearer and more limpid. As a confiderable portion of arfenic was diffolved, he wifhed to precipitate it fo as to leave the oils pure and colourlefs; and on putting a few drops of vitriolic acid to portions of them, the arfenic was depofited, leaving the oil, particularly the fpermaceti oil, as pure and colourlefs as before. Nitrous acid changed the train oil to a dark brown.

Metallic oxyds and earths on oils.

Three ounces of fpermaceti oil were digefted with one drachm of litharge for fix hours, at 200° of Fahrenheit; it became clearer, but not fo colourlefs as when treated with arfenic; the litharge was changed to a white colour. Train oil was but little affected in low degrees of heat, but in higher became difcoloured; vitriolic acid added,

precipitated the litharge from the ſpermaceti oil, and left it pure and clear, though not quite colourleſs. Nitrous acid changed them to a dark brown. Two ounces of ſpermaceti and half a drachm of red lead, digeſted eight hours, the oil was not changed; the heat being increaſed till nearly boiling, it became dark and diſcoloured. Train oil the ſame. White lead and the oxyds of copper formed on the diſtillation of acetated copper, had the ſame effect with the red lead; but leſs of the oxyds of copper appeared to be diſſolved than of thoſe of lead.

Two ounces of ſpermaceti oil and one drachm of earth of alum, precipitated from a ſolution of alum by potaſh, were placed three hours in a ſand heat from 180° to 190°. The oil became clear and colourleſs, the gluten having fallen with the earth. Train oil was likewiſe rendered much purer by the ſame means, but not equal to it. Aerated and pure magneſia precipitated the mucilage whilſt warm; but on cooling, the mucilage and magneſia roſe and mixed again with the oils. Two grains of pure lime, added to one ounce of each, turned them thick and dark coloured in the cold. In the experiments with the earths, not the ſmalleſt particle ſeemed to be diſſolved, as on the addition of any of the acids, they inſtantly changed to a very dark colour. It appears, that the metallic oxyd gives up it's oxygen to the oil, while the mucilage of the oil unites to the metal; hence, probably, in high coloured oils, the ſuperabundant carbon unites with the part of the oxygen of the calx, and forms carbonic acid, and diveſts the oil of it's colour, whilſt the oxyd attracting the mucilage, may contribute to the ſame end. Yet it is very remarkable, that an earthy ſubſtance or alumine, which is not known to contain either oxygenous or carbonic gas, ſhould diſcolour oils more powerfully than moſt of the metallic oxyds, and equally with any of them. This earth has a ſtrong attraction

for colouring matter, and on this property depends it's ufe in dying.

Animal volatile oil. The oils already mentioned, we have feen, are mild both in fmell and tafte, infoluble in water and alcohol, do not rife at a boiling heat, contain a large proportion of acid, and are already formed in the animal in a fixed ftate. In the diftillation of animal fubftances, however, and particularly of the more gelatinous kinds, when pufhed beyond the boiling point, there arifes another oil from the union of it's component parts, which are difengaged by the heat, and which oil, from it's burnt fmell, has been called an *empyreumatic* oil; it comes over with a quantity of volatile alkali, is more or lefs dark coloured according to the quantity of carbon it contains, and from being at firft fluid, becomes thicker and deeper coloured as the heat is increafed, until it is of the confiftence of tar. According to Spielman, the animal is fharper, according to Machy, richer in ammonia, than the vegetable empyreumatic oil. This oil, when rectified by diftillation, and in it's pure ftate, is quite colourlefs, and it is called, from it's volatility, *animal volatile oil*, or *oleum animale Dippelii*; and poffeffes many different properties from the fixed oils before mentioned. Animal volatile oil. Its properties different from the fixed oils.

It has a ftrong penetrating aromatic fmell, a ftrong fharp tafte, but by far not fo difgufting as the empyreumatic oil; it is perfectly tranfparent, and, after æther, the lighteft of all fluids, fince a flafk that contains half an ounce and fix grains of the beft æther only holds half an ounce and fifteen grains of this oil; it is likewife nearly as thin and volatile.

It is in part foluble in water, and by repeated agitation with it, changes the fyrup of violets green, arifing, according to Parmentier, from it's ammonia.

With the vitriolic acid it forms, according to Achard,

an acid ſoap, and it ſeparates it from the muriatic acid in that ſtate.

Muriatic acid diſſolved it at the boiling point, and it became black and thick; with four parts of this acid there was even an incipient ſolution in the cold, and the mixture became brown.

Diluted nitrous acid, according to Leonhardi, produced a purple colour with it, but at the boiling point, converted it into a dark blue, foaming, thick maſs: with ſmoking nitrous acid it inflames, and when concentrated, takes it from the muriatic acid, and forms with it a black reſin.

The acetous acid diſſolves it.

Crell obtained a ſoap with the vegetable, and the oil from ſuet; and Schulze obſerved, that an aqueous ſolution of the alkaline ſoap, made by long trituration with Dippel's oil and tartar, precipitated Pruſſian blue from a ſolution of vitriol of iron. Alkalis alſo ſeparate this oil from the muriatic acid in the ſtate of ſoap.

It is diſſolved by ſpirit of wine.

Expoſed to the atmoſphere, it becomes coloured, firſt yellowiſh, then brown, and loſes it's tranſparency.

It does not change the colour of litmus paper, or ſyrup of violets, ſo as to ſhow the preſence of an acid or alkali.

Opinions concerning the preſence of an acid in it.

Hildebrandt thinks it differs from vegetable ethereal oils only by the phoſphorus it contains. The properties of this animal volatile oil ſufficiently ſhow the difference between it and the other animal oils; but, according to Macquer, the moſt diſtinguiſhing character is, that all other animal and vegetable oils contain an acid, which appears on diſtillation, whilſt this, on the contrary, appears to ſhow ſomething of a volatile alkaline nature. Pœrner, however, is of opinion, that although on the firſt appearance this oil may ſeem different from thoſe of vegetables, yet it is the ſame oil which has undergone a

change from the difference of the body in which it refided; for if animal and vegetable oils be pufhed to their greateft ftate of fluidity, and are deprived of all foreign matter, no difference will be obferved. To this may be added, as Leonhardi obferves, that although a free acid or an alkali has not been proved to exift in this animal oil, either in it's empyreumatic or pure ftate, or in other empyreumatic oils, yet the prefence of an united acid, or a bafis capable of becoming fo in them, may be concluded. 1ft. From the refemblance to all other oils. 2d. From the change of colour to a brown, when this volatile oil is expofed to the atmofphere; and Demachy found that when this oil was digefted with cauftic ammonia it remained colourlefs; on the contrary, acids foon coloured it, from which it is fuppofed that it's brown or dark colour, when expofed to the air, arifes from a difengaged acid, or from the addition of vital air, the acidifying principle. 3d. From the foliated matter obtained by Crell, on evaporating an aqueous folution of the fediment, produced from a mixture of empyreumatic oil, with the vitriolic and nitrous acid united, which perhaps might be the oxalic acid. 4th. From Dehnen's ammoniacal falt in cryftals from fpirit of hartfhorn, and Schulze's experiment in the precipitation of Pruffian blue, already related; where the prefence of phofphoric acid was fuppofed.

Subftances the beft to produce it.

Although all animal fubftances afford this volatile oil by diftillation, yet all of them are not made ufe of for that purpofe. Thofe parts only are to be chofen which contain the pureft gelatinous matter, and are free of all fat particles; fince they produce, at the fame time, an acid which is feparated with difficulty; hence, to procure it in it's beft ftate, neither the flefh, bones, nor even the blood of animals are chofen, but the different forts of horns, particularly hartfhorn, as they afford a large quantity of pure gelatin, which is the moft productive of oil.

Methods of preparing it. With refpect to the manner of preparing it, feveral methods have been recommended. It is found neceffary at each diftillation to change the veffels, or at leaft to cleanfe thofe which have been ufed; as the leaft particle of the thicker and lefs volatile parts is fufficient to fpoil a large quantity of the more volatile oil. According to *Model*, a quantity of empyreumatic oil of hartfhorn is to be put into a clean retort, and having wrapped fome well wafhed linen round the mouth, it is to be fubjected to the gentle heat of a fand bath: when a few ounces of pure oil are come over, which arifes after the aqueous part, and a coloured oil is beginning to fhow itfelf, the receiver is to be changed; and the oil which firft came over being again diftilled, will be found pure and good. By this means as good an oil is obtained as that got by former chemifts, after 50 or 60 diftillations. A ftill better method, he found, was, to diftil the firft volatile portion, with four or five times it's quantity of diftilled water; it is then clear and pure; he has even fometimes experienced, when the empyreumatic oil was not too thick, that by the addition of water, the volatile oil was obtained fufficiently pure, without undergoing a fecond operation. *Tiböl*, an apothecary at Groningen, recommends the empyreumatic oil of hartfhorn to be mixed with three or four parts of warm water, and digefted for 24 hours; it is then to be put into a retort, taking care not to let it touch the neck; a receiver is to be luted to it, and the day after, it is to be diftilled by a gentle heat in the fand bath: the firft oil that comes is yellow, and mixed with a volatile alkaline fluid; the next is purer, and the laft black and thick. Hence the receiver is to be changed three times; the fecond oil is to be diftilled again, and the pureft part to be rectified with an equal quantity of water. *Dehne* is faid to have improved the method of *Model*, by advifing to make ufe of a cucurbit in the diftillation of the pure oil

Model.

Tibœl.

Dehne.

from the oil of hartſhorn, as the difficult cleanſing of the neck of the retort may be diſpenſed with; and when the alembic becomes diſcoloured with yellow oil, it may always be replaced by another. In this manner, from rectifying the yellow and red oils, got from two pounds of oil of hartſhorn, which ariſe after the white, together with the laſt, he obtained rather more than 5 1/4 ounces of beautiful pure Dippel's oil. Previous, however, to this chemiſt, Schulze had already mentioned the uſe of a cucurbit with it's alembic in this proceſs, in which, to ſpare the repeated rectification, he adviſes to extract the oil from unquenched lime; but as the heat ariſing from the lime might change the white tranſparency of the oil, as Crell found heat to have this effect, it is better let alone. Although the name of Dippel has been given to this volatile animal oil, he was not the firſt chemiſt who diſcovered it, as Van Helmont had already mentioned it in his *Aurora Medicinæ*; and Homberg, it appears, had likewiſe prepared it from the human excrement; and according to Schulze, Count Wittgenſtein had obtained it from the ſame ſubſtance, at Berlin, in the higheſt rectified ſtate.

As this oil is very much inclined to loſe it's whiteneſs and become leſs fluid by only expoſing it a ſhort time to the atmoſpheric air, from the evaporation of it's more volatile parts, and the dark colour which the remaining leſs volatile oil receives, it is neceſſary, in order to preſerve it pure, to put it in ſmall vials as ſoon as it is prepared, provided with ground ſtoppers, over which caps of bladder or lead are tied. Deyne adviſes a few drops of diſtilled water to be previouſly poured upon the top of the oil. Method of preserving it.

This oil has been uſed in medicine: it was recommended by Dippel, to be given a few hours before the attack of the paroxyſm of a fever, in a doſe of between Recommended by Dippel in fevers.

thirty and forty drops, and it was ſaid to procure ſleep, and prevent another paroxyſm. It has likewiſe been uſed by, and mentioned in the writings of Frederic Hoffmann, Junker, Boerhaave, Vater, Haller and Lober, Machard and Reinhard, Ludolf, Hartmann, Foxe, Baumer, Parmentier, and others, who have recommended it in various diſeaſes, and attributed very great effects to it. It is prepared according to the preſcription of the laſt London Pharmacopœia, by diſtilling one pound of the oil of hartſhorn three times, by the name of oleum animale.

And by other phyſicians.

The component parts of oils are hydrogen, carbon, oxygen, and phoſphorus; but from the want of azot, they are not looked upon as perfectly animalized.

As there have been various opinions reſpecting the uſes of oil in the animal body, different hypotheſes have been invented of it's formation.

Opinion of the formation of oil in the animal body.

Both the uſes and formation of it are, however, obſcure. With reſpect to it's formation, one of the moſt probable theſes is that of Dr. Beddoes, which, although it explains many facts hitherto inexplicable, is ſubject to many exceptions. The foundation on which it reſts is, that whenever there is a certain diminution of oxygen in the animal ſyſtem, fat will be produced. The following obſervations, according to Coindet, ſeem to ſupport this aſſertion. The chemical analyſis of fat ſhows, that ſix parts of it contain nearly five of carbon, and one of hydrogen, and ſome ſebacic acid. The fat parts of animals only differ from the fleſhy, in the laſt containing azot and more oxygen. By this means the change of muſcles into a ſubſtance like ſpermaceti in the churchyard of the Innocents at Paris has been explained by Fourcroy, and it has been obſerved, that fat in the living body increaſes at the expenſe of the muſcles, and vice verſa.

The want of oxygen, conſidered as a cauſe of corpulency, is indicated by the analogy which exiſts between

obesity and the sea scurvy, which seems only to be owing to a gradual abstraction of a part of the oxygen in the system. The sea scurvy is never announced by meagerness, for a fullness of the habit is the first symptom of the disease. Dr. Trotter observes, that when a negro becomes rapidly corpulent, he never fails to be attacked by the scurvy, from which, according to the comparison of Dr. Beddoes, it appears, that corpulency is to the scurvy what cachexy is to dropsy. According to Saussure and Humbolds, the atmosphere of high mountains contain less oxygen than that of lower regions, which explains why Condamine was attacked by scorbutic symptoms on the summit of Pinchina. All the symptoms of scurvy prove likewise that it arises from a privation of oxygen: thus the surface of the body is covered with livid spots, the arterial blood is very little fluid; and after death, the left auricle is filled with venous blood; which Dr. Goodwin found in animals that had been deprived of life for want of oxygen. Dr. Lind informs us, that when death has been sudden, and no effusion is found in the cavities of the body, the auricles and ventricles are filled with blood, and especially the left side of the heart, which is the more remarkable, since that side rarely contains much blood after death.

Country people know from experience, that to fatten poultry, they must be kept in darkness; that substances proper for prolonging their sleep must be mixed with their food, as tares, or spirituous liquors. It is a curious circumstance, that the age when the secretion of fat is most considerable is about the 40th year, a time when the arterial system ceases to act such a conspicuous part in the animal œconomy: either, as Dr. Coindet thinks, it is then ossified, or in part obliterated, while the venous system coming more and more into action, acquires that influence so considerable in old age. Perhaps the arte-

ries, the action of which is then visibly diminished, furnish the system with less oxygen at that period, which may be looked upon as the cause of the corpulency of middle aged people.

It may be objected, that children, whose venous system is not yet developed, have, however, a remarkable plumpness. But this difficulty has been resolved in the following manner: The venous blood, when it arrives at the lungs, undergoes changes that are well known; and it may happen, that as respiration is more or less perfect, the blood may lose a greater or less quantity of carbon or hydrogen. In proportion as it loses less, the secretion of the fat will be more abundant, which affords an explanation of the enormous quantity of fat in amphibious animals, and fish, whose respiration is imperfect. They retain, therefore, more hydrogen and carbon, which passing into the arteries, Dr. Coindet thinks, occasion that considerable secretion of fat, and probably produce that voluminous size of liver, found in fishes, in which the circulation is such, that almost the whole blood goes to the liver, either to operate there a secretion of fat, or of bile, the constituent parts of which do not differ much from those of the former. The same reason may be given why children, who do not respire in the womb, have a full habit of body until the third or fourth year, for the foramen ovale is not obliterated until that period. This seems to be confirmed by the observations quoted in the medical transactions of London, and by those of professor Sandifort, of Leyden, which give an account of individuals remarkable for their corpulency, in whom it was found on dissection, that the foramen ovale was not closed up, from which it appears, that the greater part of the venous blood passed directly from the right into the left ventricle, to be trasmitted to the aorta, and thence to circulate through the whole system, without having undergone

any of thofe changes which blood undergoes in the procefs of refpiration. Their lungs were diminifhed in fize, and in a collapfed ftate, which indicated they had not difcharged all the functions of refpiratory organs; hence the enormous fize of the liver in the fetus, and the reafon why difeafes of the liver, fuch as fcirrhous tumours, &c. are incident to people who are more or lefs corpulent. The blood of plethoric, or of fat people, is alfo commonly of a darker colour, and more vifcous than that of lean people, which laft is generally very fluid. Thofe who drink cider are more meager than thofe accuftomed to beer, porter, or other liquors of the fame kind. In Holland, and in fome parts of England, the inhabitants are very corpulent, whilft in France they are thin, from the fame caufes.

The facts and obfervations already made on the formation of oil, are fufficient to inform the reader, that future experiments are neceffary to render it complete.

Encycloped. Méthod.—Macquer's Worterbuch by Leonhardi, art. Fett, and Thierifches Oel.—Crell's Zerlegung des Walraths in his Chem. Journ. 1778.—Neumann's Chem.—Sur les différens Etats des Cadavres trouvés dans les Fouilles du Cimetière des Innocens, par M. Fourcroy, An. de Chemie, fecond memoir, Tom. 8. p. 17.—On the converfion of animal fubftances into a fatty matter, &c. by G. S. Gibbs, B. A Phil. Trans. 1794, and p. 2. 1795.—Plenck's Hygrologie, art. Fett.—Parmentier & Deyeux fur le Lait, &c. art. Beurre. —F. De Machy de Oleor. ex Animal. rect. &c. Nov. Act. Acad. T. 5.—Janffen's Abhandl. von Thierifch. Fett, tranflated into Latin by C. Jonas, Halle, 1786.—Cafper Neumann von Knochenmark, in his Med. Ch.—B. Tibol ueber die Bereitungfart von Dippels Thier. Oel in

the Abh. der Harlem, &c. T. 12.—Dehne ueber Dippel's Th. Oel in Crell's Chem. Journ.—Obſervations on animal Fat, &c. by Dr. Coindet, in the Journal de Phyſ. 1798, and Med. and Chirurg. Review, vol. 5.—Rapport ſur la Fabrication des Savons, ſur leurs différentes Eſpéces, &c. par les Cit. Darcet, Lelievre et Pelletier, Annal. de Ch. T. 19. p. 253.—On the Action of metallic Oxyds and Earths upon Oils, &c. by Mr. P. Henry, 1792.—Mancheſter Memoirs, vol. 4. Part 1. 1793.

ACIDS.

Animal acids had been ſo little inveſtigated at the time of Macquer, that he informs us in his dictionary, it was not perfectly aſcertained whether they were eſſentially different from thoſe of vegetables. That they differed from the mineral acids, was granted; and it was thought probable, in the ſame manner as the vegetable acids differed from them, viz. by a portion of oil which they appeared to poſſeſs. He has only mentioned three of theſe acids, that *of fat*, *of ants*, and the *phoſphoric acid*. A very few years afterward, a great addition was made to this claſs; for

Their number, according to Macquer.

we find that Morveau in the Encyclopédie Méthodique has reckoned ſix acids in the animal kingdom, viz. the *phoſphoric*, *pruſſic*, *formic*, *ſebacic*, *galactic*, and *ſaccharo-galactic*, or *ſaclactic*. To theſe he afterward added three more, the *lithic*, the *bombic*, and the *gaſtric*. It appears, that the weakneſs of ſome of theſe acids was attributed to the oil, which was ſuppoſed to enter their compoſition; and this chemiſt propoſes to examine the truth of it's being an eſſential part, and ſurmiſes, that perhaps it may be ſeparated from them in the ſame manner as the colouring extractive matter is ſeparated from the acetous acid; this being done, he thinks they would become more ſtrong, and perhaps reſemble ſome of the acids already known; and that it is very probable that the acids procured from all fat ſubſtances might be ſo purified, as to be identic with the ſebacic acid.

Mo veau.

Ker, who publiſhed his dictionary in 1789, nearly three years after the work of Morveau appeared, but had no opportunity of conſulting it, has treated as animal, *the acids of ants*, and ſome other *inſects*, *of fat*, *of milk*, *perlated acid*, *the phoſphoric*, and the acids of *Pruſſian blue*, and *of ſugar*

Ker.

of milk. This chemist was of opinion, that these acids had been so little investigated, as not to make it certain whether they were essentially different from those obtained from vegetables; "but we are certain," says he, "that they differ in the same circumstances as the vegetable acids do from mineral acids; and probably, this difference proceeds from the same cause, which constitutes the difference betwixt the vegetable and mineral acids, viz. the combination of oily particles with the former."*

When the nature of these, as well as acids in general, were better understood by a further investigation of their properties and component parts; the French chemists, and more particularly Lavoisier, made a new division of them, according to their component parts; hence Fourcroy in his *Philosophie Chemique* has placed the animal acid in the fourth class of acids, having their radicals composed of three bases, at least, viz. of carbon, hydrogen, and azot, which united to oxygen, in various proportions, form the peculiar acid; and these he calls acids with ternary radicals; to which Lavoisier had added phosphorus, but not as an essential part. They are the least known of all the acids, but have some properties, which may be considered as classic characters; such are the properties of affording ammonia on decomposition by fire, and of giving the prussic acid by a change in the proportion of their principles.

Fourcroy.

According to Fourcroy, the prussic acid appears, to this class of acids in general, what the oxalic is to the vegetable acids; to which may be added, that on converting animal substances into oxalic acid, by the action of the nitric acid, prussic acid is constantly formed during the action, which is disengaged in the form of vapours. This chemist has distinguished seven animal acids, viz. *the lactic*, *saccho-lactic*, *sebacic*, *lithic*, *formic*, *bombic*, and *Prussic*. From the diversity of opinions, respecting which are

or are not to be ranked as animal acids, it is evident, that principles are ftill wanting upon which their diftinguifhing characters are to be founded : and if, in the formation of this clafs, all thofe acids are to be excluded, which are not folely procured from the animal kingdom, feveral acids will be refufed admiffion, which to all appearance are of animal origin.

With refpect to the phofphoric acid, the illuftrious Bergmann confidered it as belonging to all the kingdoms. Morveau, however, is of opinion, that although we have no direct proofs, there is fome reafon to believe, that it belongs exclufively to the animal. He fufpects that it is only carried accidentally to the mineral and vegetable parts of the creation, with the other wrecks of animated bodies, and that it is preferved only by reafon of it's fixity, or on account of that indeftructibility which is known to be one of it's principles. "If," fays he, "this acid is found without having undergone any alteration amongft offeous matter, which has been inhumed for ages, as Berniard has proved from the analyfis of a piece of the *montagne aux os* of Gailenruth, in the margravate of Bayreuth; it is evident, that the moft powerful agents of decompofition, the moft energetic mineral menftrua, cannot even by the aid of time refolve it's radical principle into it's elements, and are confined to depriving it of it's bafis only under certain circumftances." He however confeffes, that this hypothefis has no other foundation than the great proportion of phofphoric acid which all animal matters afford, and which living animals daily furnifh in their excrements, and the quantity compared to that which may be fuppofed to exift in their aliments. Phofphoric.

The febacic acid is common to both vegetable and animal oils. Sebacic.

The zoonic acid, firft difcovered by Berthollet, in the Zoonic

diſtillation of animal ſubſtances, is likewiſe found in ſome vegetable matters, on ſubmitting them to the ſame proceſs, as in the gluten of flour, yeaſt, &c.

There are other acids which have likewiſe been extracted from animal ſubſtances, which have not only a leſs title to being called animal, but which evidently do not belong to them. Thus Berthollet has been able, by the means of nitrous acid, to extract the oxalic acid from ſeveral animal ſubſtances; and Scheele diſcovered the malic acid, and it appears, that theſe two acids generally accompany each other. It is neceſſary, however, that the nitrous acid be concentrated. Scheele poured two parts of fuming nitrous acid upon one part of glue, and placed the mixture on a ſand bath, the glue was ſoon diſſolved, emitting deep red vapours. The next day, he found a number of cryſtals of the oxalic acid, which had been formed on the ſolution becoming cool, and the reſt of the liquor which refuſed to cryſtallize, being ſaturated with chalk, the malic acid was eaſily diſengaged from it. Iſinglaſs, white and yolk of the egg, and blood treated in the ſame manner, afford the ſame products. There are three important obſervations to be made on theſe decompoſitions of animal matters. 1ſt. A fat thick ſubſtance is always ſeparated. 2d. If the gas be collected, which ariſes during the operation, a little carbonic acid is found in it; a good deal of azot gas, and a ſmall quantity of nitrous gas; it is more particularly with the yolk of the egg that theſe phenomena are the moſt ſenſible. Scheele did not find the azot gas (air phlogiſtique) when he procured the oxalic acid from vegetable ſubſtances. 3d. Every time the oxalic acid is prepared, there paſſes into the receiver, after the nitrous gas, a ſmall portion of acetous acid. Crell obſerves, that this fact had been made known by Scheele and Weſtrumb nearly at the ſame

Oxalic and malic.

time, and before they could know each other's difcovery.

Scheele having fubmitted to the fame operation what Rouelle has very well named, the *faponaceous extract of urine*, which is obtained as before related, by evaporating it to the confiftence of honey, and having then digefted it in fpirit of wine, to feparate the greateft part of it's falts, and evaporated the fpirituous folution, which leaves a faponaceous extract equally foluble in water or alcohol, found, that this matter afforded no oxalic, but fome *benzoic* acid, which was in a ftate of a benzoat of ammonia. This acid does not appear to be formed during the operation with the nitrous acid, becaufe it is only neceffary to diffolve this urinous extract in a little water, and add to it fome vitriolic or muriatic acid, in order for the liquor to become immediately turbid by the precipitation of the concrete benzoic acid. The celebrated Rouelle had well obferved, that this faponaceous extract contained a good deal of volatile alkali, but he did not know the acid to which it was united. Benzoic.

The benzoic acid is alfo procured by diftillation from the faccholactic acid; and the confequence which Scheele draws from it is, that it undergoes no alteration in the circulation of the blood. This fupports the idea of Morveau, that vegetable acids may pafs into the animal kingdom without lofing the characters that difclofe their origin. The chemift ought not to neglect to follow thefe acids into thefe emigrations, becaufe it is only by fuch means that the fyftem of their properties can be completed, their analyfis rendered exact, and a folid bafis prepared for phyfiological inveftigation. To thefe may be added the acetous acid, which is obferved to be produced from the fpontaneous fermentation of broths. Acetous.

Having thus given a fhort account of the acids that are found in vegetables, as well as in animals, it may be ob-

ferved, that thofe acids which are purely of animal origin are few in number, fix being perhaps the utmoft, and are the following, *formic*, *lactic*, *faccholactic*, *bombic*, *lithic*, and *amniotic*; they are faid by Fourcroy, as before obferved, to be characterized by affording ammonia and the pruffic acid by heat. As, however, the *phofphoric*, *febacic*, and *zoonic* acids, may be fuppofed to derive their origin from thofe parts of vegetables which may be looked upon as animalized in a greater or lefs degree, it has been thought proper to admit them in the prefent article of animal acids, till future inveftigation fhall determine to what clafs they really belong. With refpect to the pruffic acid, as it is evidently an artificial acid, it has been left out. The number of acids therefore which are fuppofed to derive their origin and characters from the procefs of animalization may be extended to nine.

Other acids fufpected in the animal kingdom.

Befides thefe, the animal kingdom is fuppofed to afford others, particularly amongft infects, but which have not as yet undergone any chemical inveftigation; and it is fufpected, that the generality, if not all of them, are capable of affording an acid liquor, which they contain in a difengaged ftate.

Thus, it has been long ago obferved by Hooke, that infects of the hymenoptera clafs, which are furnifhed with ftings, fuch as bees, wafps, hornets, are alfo provided with an acid liquor, which they difcharge on being irritated, in their own defence. Some of the clafs diptera, as the mofchetto and the fmall gnat, have been obferved, on flying into the mouth, to imprefs a manifeft acidity on the organs of tafte; and Fourcroy has often obferved, that the bupreftis and ftaphilinus of the coleoptera clafs reddened the blue paper of fuch boxes as they were confined in. Chauflier has drawn an acid from the grafshopper, the red bug, the lampyris, and feveral other infects, by means of digeftion in alcohol. Lifter indi-

cates a ſpecies of millepedes (Collect. acad. T. 2. p. 303.) which contains an acid. Leonhardi informs us, that an acid may be extracted from the locuſt by alcohol, whilſt Dehne found one in the meloe proſcarabæus and maialis; (Crell's N. Ent. xiii. 166 f.) and Bonnet has obſerved, (Savans etrang. T. 2. p. 276.) that the liquor ſpurted by the great caterpillar of the willow in it's own defence is an acid, and very active in it's effects, by occaſioning a ſenſe of burning; that it is perfectly clear and colourleſs, and ſmells and taſtes like concentrated vinegar, to which Bergmann compares it; that it coagulates blood, depoſits a coagulable lymph in alcohol, and reddens the blue paper of litmus; but, however, from it's great volatility is ſoon diſſipated.

Formic acid.—There can be no doubt that the ſtrong acid ſmell which is obſerved to ariſe from the atmoſphere of an ant-bed, after being diſturbed, muſt have been known to the ancients, but from their want of chemical knowledge, it is not very extraordinary they ſhould have been ignorant of it's being owing to a peculiar acid. According to Morveau, it was not till nearly the end of the 15th century, that ſome botaniſts obſerved, with ſurprize, that the blue colour of the flower of the cichory, when caſt into a heap of ants, *became as red as blood.* Mention of this fact is made in the works of Langham, Hieronimus Tragus, Othon Bransfeld, and John Bauhin.

Formic acid.

It's hiſtory.

In 1688, Hunerwolf publiſhed an account, in the Ephemerides of Germany, of a fuller having been cured of a head-ach, to which he had long been ſubject, as he was ſtanding over an ant-bed, in order to procure ſome of the inſects; and that his hands had been excoriated by the acid liquor they emitted.

Fiſher.

This acid liquor, however, was not thoroughly eſtabliſhed as an acid, and procured in a liquid form, until Samuel Fiſher

obtained fome on treating animal fubftances by diftillation; he tried it's action on lead and iron, and communicated his obfervations to John Wray, who inferted them in the Philofophical Tranfactions for the year 1670; which diftillation has fince been defcribed by Etmuller in his works on pharmacy.

Hoffmann. Hoffmann afterwards extracted fpirit of wine from thefe infects, and called the product he obtained, in the alchemical ftyle, *water of magnanimity*.

The exiftence of this acid was alfo proved by Sperling, Homberg, and Cafper Neumann; and numerous experiments were likewife made upon it by the celebrated Margraaf; but for the beft differtation on this fubject we are indebted to Arvidfon and Oehrn.

Margraaf. Margraaf examined it in 1749, and it is from his experiments that Macquer has compiled the article of this acid in his excellent dictionary. Margraaf found, that when thefe animals were fhaken, either in water or fpirit of wine, they communicated an acid tafte; that this acid is fo volatile as to arife with the alcohol in diftillation; but that the greater part is fufficiently fixed to remain united with the remaining phlegm; that all the acid may be obtained from thefe infects, on fubmitting the water charged with them to diftillation in a water bath. Margraaf obtained 11 oz. 2 drachms of acid fpirit from twenty-four ounces of frefh ants without any addition. He found that this acid had the principal properties of other acids, that it formed deliquefcent cryftals with fixed alkalis, which expofed to a great heat gave two fluids, the one fcarcely acid, and the other urinous or alkaline; whilft the remainder, diffolved in water and evaporated, afforded large cryftals, which had all the properties of fixed alkalis. If, however, the vitriolic acid be poured on thefe alkaline cryftals, white vapours arife, although no acid is procured by diftillation. From thefe white

vapours, and the eafe with which this falt cryftallizes, Margraaf conjectured the prefence of a concealed acid. With the volatile alkali it formed an ammoniacal fluid, which was equally as uncryftallizable, as if vinegar had been ufed inftead of this acid. It formed cryftallizable falts, however, with unquenched lime, chalk, and coral.

With refpect to metals, Margraaf found that it had but little or no action on filver, lead, tin, and antimony, fomewhat more on copper; whilft it fhowed a very ftrong menftrual power on iron and zinc. It likewife diffolved the calces of filver, copper, lime, and lead; but had no effect on thofe of mercury, bifmuth, and antimony. It vitrifies the calx of mercury.

From this acid not precipitating filver, lead, or quickfilver, from their folutions in nitrous acid, this chemift affirms it has no fimilarity with the muriatic acid, and from it's not taking lime from the muriatic acid, that it does not agree with the vitriolic; but concludes from the above experiments, with which Macquer coincides, that it has many, but not all the properties of vinegar.

In the year 1770, that moft excellent chemift Rouelle, having previoufly confirmed the above facts by experiments, expofed them in his lectures to the ftudents in the king's garden. We are told, by Macquer, that he had obtained the fame products from thefe infects as Margraaf, with a fmall difference in the quantity of oil obtained by diftillation. Rouelle.

In 1777 Arvidfon and Oehrn endeavoured to compleat our knowledge of this acid in an excellent differtation, which they publifhed at Leipfic, and which has principally ferved Morveau for his account of it in the Encyclopédie Méthodique. Arvidfon and Oehrn.

It appears from thefe two chemifts, that all fpecies of ants are not equally good for the extraction of this acid. Thus, the fmall red ant, commonly found in gardens,

affords very little of it; the fame may be faid of thofe fpecies called by Linnæus, *herculanea*, *fufca*, *cefpetum*: the fpecies which fupplies it in the greateft quantity is of a reddifh colour, and of a middle fize, called by Linnæus, *formica rufa*; it generally inhabits the woods, but is fometimes found in gardens and in fields near cities, more particularly in places that are a little elevated and dry.

The fpecies that affords it in the largeft quantity.

Seafon for procuring them.

Every feafon is not proper for their collection; they contain the moft acid during the months of June and July; at this time it is only fufficient to prefs one of thefe ants on a piece of paper coloured blue by litmus, to give it the moft lively red colour: they will fometimes even leave fpots of this colour by fimply marching over it; when this happens, it is a proof that the fpecies and the feafon cannot be better chofen.

Method of collecting the ants.

In order to collect them, fmall fticks muft be placed over the ant bed after it has been opened; and when the ants have attached themfelves to this, they are to be fhaken off into a large earthen veffel filled with water, until it is fo full as not to be able to deftroy any more; they are then to be cleanfed of all foreign matter, and gently dried; they are then fit for ufe.

Two ways of extracting the acid. 1. By diftillation.

To extract the acid from thefe ants there are two methods, viz. by *diftillation*, and by *lixiviation*. With refpect to the firft, a glafs retort is to be filled half full of them, a receiver affixed, a gentle heat is to be applied, and augmented by degrees, until all the acid has paffed over. In the receiver the formic acid is found, which is very acid in a liquid ftate, with a little empyreumatic oil on it's furface, which muft be feparated by means of a ftrainer previoufly fteeped in water. In this manner Arvidfon and Oehrn extracted feven ounces and half of acid from one pound of ants, the fpecific gravity of which, at a temperature of 15° above zero, was to that of water

as 1,0075 to 1,0000. Morveau informs us, that he obtained from 49 ounces of ants, 23 ounces 2 drachms of a pretty ſtrong acid. Some pour a little water into the retort, but this only ſerves to weaken the acid.

Theſe chemiſts have found another way of procuring this acid, which is leſs embarraſſing: the ants are firſt to be waſhed with cold water, they are then to be extended upon a clean linen, and boiling water poured on them; when the water becomes cool, freſh boiling water is to be poured on them, and repeated a third time, or until all the acid is extracted; the linen is then to be ſtrained, and the water, to be collected and filtered.

By this means, from one pound of ants, about one pint of formic acid was obtained, as ſtrong as vinegar, and the ſpecific gravity of which was greater. Theſe chemiſts are of opinion, that this acid might ſupply the place of vinegar for economical purpoſes. If it is to be kept, it muſt be deprived of it's oil, which the filter cannot compleatly ſeparate, a part of which is fat oil, and the other part eſſential oil, which renders it turbid and diſpoſes it to putrefaction; hence they adviſe it to be boiled ſeveral times, and with precaution, and thus purified they eſteem it preferable to vinegar.

For chemical experiments, however, it is neceſſary to rectify this acid, which is done by repeated diſtillations by a gentle heat, in veſſels ſomewhat elevated, until no more oil remains, *i. e.* until it becomes colourleſs, it being impoſſible entirely to deprive it of both theſe oils: for it appears, that even after four rectifications, the fat oil was ſtill evident by an empyreumatic odour, and the eſſential oil by the zones that were formed. This empyreumatic odour flies off on expoſure to the air; or ſtill better by concentration from freezing; but as to the eſſential oil, it appears to be a conſtituent part of the acid, and is inſeparable. The ſpecific gravity of the acid thus

2. By lixiviation. rectified they found to be as 1,0011. The other procefs to obtain the acid is that of Thouvenel, by lixiviation, which he looks upon as the moft eafy. It confifts in placing linen cloths impregnated with fixed alkali upon the ant beds, and the falt afterwards is to be extracted by lixiviation; but this procefs, it is obferved, can only be of advantage when the acid is wanted to form a neutral falt with an alkaline bafis.

Hermbftadt does not approve of the method either of Margraaf or Arvidfon of obtaining the formic acid; for in the one cafe the acid is in part deftroyed by the fire, in part rendered impure by the decompofed oil; but in the other cafe it is too much weakened by dilution with water. He procured it much purer by expreffing it from two pounds of dry living ants, from which he obtained twenty-one ounces and a quarter of a brown mucous acid juice. It had an acid aroma by no means unpleafant, and penetrating like the vapour of the acid of fluor. In tafte, it refembled more the acid of tartar than vinegar.

From this he obtained by diftillation, fix ounces and half of pure formic acid.

From the experiments and obfervations of Arvidfon and Oehrn, it appears, that the formic acid has the following properties.

Properties of the formic acid. The fpecific gravity, when well rectified, is to water as 1,0453 to 1,0000.

It affects the eyes and the nofe in a peculiar manner; it's fmell is penetrating, but not unpleafant; it's favour fharp and burning, and when diluted with water is agreeably acid.

It retains water fo greedily as not to be entirely feparated from it by diftillation.

It reddens the blue colours of vegetables; it even changes the blue paper which enclofes fugarloaves, and converts it infenfibly to a yellow red. One part of this

concentrated acid mixed with 75 of diſtilled water, ſtill reddens, although weakly, the ſyrup of violets; diluted with 430 parts of water, it produces reddiſh ſpots on paper coloured by the infuſion of litmus; and with 1300 parts it produces effects only on the infuſion of litmus. It readily unites with other acids.

Mixed with the vitriolic acid, it blackens it, and on becoming warm there ariſes white penetrating vapours; on boiling, an elaſtic gas is extricated, which unites difficultly with diſtilled water and lime water. On diſtilling this mixture, the formic acid is again obtained in ſmall quantity.

Boiled with the nitrous acid, there ariſes phlogiſtic vapours, and a ſpecies of gas very little miſcible with water, and which renders lime water turbid.

In this operation the formic acid is deſtroyed, and is not again obtained by diſtillation, eſpecially if a large quantity of very concentrated nitrous acid has been uſed.

Heated by itſelf, it affords elaſtic vapours, which conducted through a cold earthen tube, afforded fixed and phlogiſticated airs; through a red hot tube, inflammable air likewiſe. (Achard, in Crell's Annalen, b. 1. ſ. 527 f. Fontana looked upon it as fixed air, (Roſier's Journal de Phyſique, 1778) but it's being decompoſable by the fire into fixed and inflammable airs (Bergman, Opusc. iii. p. 378) proves this not to be the caſe.

The muriatic acid does not change the formic, from which it is ſeparated without loſs by diſtillation. This, however, is not the caſe with the dephlogiſticated muriatic acid; for it decompoſes the formic acid in cloſe veſſels, and takes away it's phlogiſton (according to the new theory, the formic acid ſeizes on the oxygen of the dephlogiſticated muriatic acid) and decompoſes it.

The formic acid appears not to be ſuſceptible of forming an immediate connection with phlogiſton.

By the aid of heat it attacks the foot of the chimney, becomes of a yellowifh colour, and on cooling, lets fall a brown fediment; if this fediment be diftilled, there comes over a liquor of a yellowifh colour, of a difagreeable odour, accompanied by elaftic vapours. Nothing of the kind is obferved when this acid is boiled with powdered charcoal.

It unites difficultly with fat and effential oils; for the acid extracted from thefe unions after digeftion, or by diftillation, has not undergone any change of colour, although impregnated with the odour of thefe oils, and after evaporation it leaves marks of a refiduum; it, however, completely diffolves the empyreumatic oil of the ants.

It does not unite with vitriolic æther.

It unites perfectly with rectified fpirit of wine, and diftilled, it afforded a formic æther, which burned with a white flame, without fmoke or refiduum. Buckholz obtained a much finer æther by procuring the acid from a formiat of potafh. He firft procured the formic acid by infufion, rectified and faturated it with purified potafh, then extracted it to drynefs, levigated it in a warm mortar, added half it's quantity of fmoking vitriolic acid, and obtained by diftillation a ftrong pellucid formic acid; to this acid he added an equal quantity of pure alcohol, and by fubmitting the mixture to a gentle heat, he obtained a fpirit of the odour of bitter almonds, which, being united with about one fourth part of diftilled water in the receiver, afforded a real formic æther. (*Vide* Crell's N. Entd. vi. f. 53 ft.)

According to the experiments of Arvidfon and Oehrn, the lee of potafh exactly faturated with formic acid had a very faline and bitter favour, but was incapable of being cryftallized or perfectly exficcated. After expofure to a ftrong heat, it became a dark green alkaline lump,

which united readily with water, and after a gradual evaporation before the ſun, ſome little of the acid dropped from it; there appeared ſome cryſtallized ſcales, of ſcarcely any ſavour; by which it reſembled *terra foliata tartari*, acetated mineral alkali, as well as by it's deliqueſcing in the air, and it's ſolubility in alcohol; by diſtillation it afforded no acid. This formiat of potaſh is decompoſed by barytes, which lays hold of it's acid; and by all acids which ſeize upon it's alkali, except the ſedative ſalt, vinegar, the phlogiſticated vitriolic and nitrous acids, and fixed air.

With ſoda it formed foliated humid cryſtals, of a bitter ſaline ſavour, ſoluble in twice their quantity of water.

With cauſtic volatile alkali, it afforded thin cryſtals, which appeared to be ſuperſaturated with the acid from their reddening blue paper; they deliqueſced in the open air. On diſtillation they afforded no acid or ſublimate, but an alkaline fluid, and there remained a dark brown maſs.

United with lime it forms a pellucid cubic ſalt, rather diſtorted, not deliqueſcent, as had been previouſly obſerved by Margraaf; efflorefcent, ſoluble in eight parts of water, inſoluble in alcohol, and of a bitter ſavour. It gives blue paper a darker colour, affords no acid by diſtillation, decrepitates on red hot coals, and becomes darker; it is decompoſed by barytes.

Equal parts of uncalcined magneſia formed with this acid a ley, from which ſome parts which were difficultly ſoluble fell down, afterward there appeared a tranſparent ſalt compoſed of ſpherical, aggregated, hairyform cryſtals, of little or no ſavour, ſoluble in 13 parts of water, but not in alcohol; lime decompoſed it. According to Bergmann (op. 1. p. 389.) it decrepitates in the fire. It is called by Bergmann *magneſia formicata*.

With barytes it formed cluſters of cryſtals, needle ſhap-

ed, which were bitter; not deliquefcent; foluble in four parts of water; infoluble in alcohol; became of a dark brown colour on burning, producing a fmell of burnt fugar; and on expofure to a red heat, a coal which effervefced ftrongly with acids.

With the pureft clay, or the dried earth of alum, it united with great difficulty, and fcarcely to faturation. The folution is fomewhat fharp and aftringent.

The formic acid has no action upon filiceous earth.

It does not affect either platina, or gold, or quickfilver.

It converts copper into a light green calx. It formed with it's calx a beautiful blue folution, from which blue cubic cryftals arofe, of the naufeous favour of verdegrife; becoming white by efflorefcence in the air; foluble in feven parts of water; burning with a green flame; not decompofed on diftillation; decompofable by all the acids, except vinegar and fedative falt, as well as by lime, manganefe, iron, lead, regulus of cobalt, and tin.

It diffolves iron with a ftrong effervefcence, producing inflammable gas. The folution depofits ochre, and affords fometimes reddifh yellow threadlike cryftals, of an aftringent favour, eafily foluble in water, diffolving difficultly in alcohol; which abandon the acid, with depofiting black particles in water, and are decompofed by all acids, as well as by zinc and manganefe.

It diffolves zinc likewife with a ftrong effervefcence, producing inflammable gas. The clear, moderately aftringent folution affords clear cryftals, growing together, fometimes cubiform, infoluble in alcohol, difficultly foluble in water, which fwell and become milk white on burning, melt with a penetrating fmoke, afford afhes, and are decompofed neither by vinegar nor by metals.

It calcined, but fcarcely diffolved, bifmuth. From the fparing folution arofe cryftals that were foluble in water, became black on expofure to fire, and were decompof-

ed by all acids, except vinegar, and by all metals, except ſilver, in the moiſt way.

By the affiſtance of heat it has ſome little ſoluble power on lead, and produces glaſslike cryſtals.

It can only be united to tin and it's calces by digeſtion and a boiling heat. Part of it is in the form of a white calcined powder, and part a jelly difficult to be exſiccated. The powder is inſoluble both in water and in alcohol, and burns firſt to a black, then to a white colour, afterward it flies off. The gelatinous flakes are precipitated by alcohol in the ſtate of a pulverized calx. Vinegar produces no precipitation, but all acids which diſſolve tin decompoſe it; lead produces the ſame effect.

It has no effect on antimony, arſenic, cobalt, and nickel, in their metallic ſtate; it however acts upon their calces. By digeſtion with the calx of cobalt, precipitated by an alkali, it produced a pale purple ſolution, from which aroſe red coloured, irregular cryſtals; that were inſoluble in alcohol, difficultly ſo in water, but were eaſily taken up by acids, and formed a ſympathetic ink; they were decompoſed by tin.

Digeſted and boiled with the calx of nickel, precipitated by an alkali, it formed a clear green ſolution, from which aroſe green threadlike cryſtals, aggregated in ſemiglobular forms, of difficult ſolution, which on diſtillation became yellow. They were neither decompoſed by biſmuth nor vinegar.

With the calx of mangaueſe precipitated by alkali from it's nitrous ſolution, it eaſily formed a ſolution with effervеſcence; the cryſtals ariſing from it were coloured and ſoluble in 15 parts of water, but inſoluble in alcohol, they had very little ſavour and no action on the colour of the tincture of litmus. Alkalies, earths, and zinc decompoſed them, and ſeized the acid; whilſt all the acids, except vinegar, laid hold of the metallic part.

2

With the calx of arfenic it produces granular cryftallizations, which are difficultly foluble, according to Bergmann (Opufc. II. p. 296.)

It diffolves minium without the affiftance of heat; the cryftals arifing from the folution are prifmatic, larger than thofe from a folution of the metal in this acid, fweet and aftringent to the tafte, and foluble in 36 parts of diftilled water; with other water they produce a milky appearance. They decrepitate in the fire, melt, become black, and of a difagreeable fmell, but afford no acid by diftillation, although this falt is fuperfaturated with acid, and reddens blue paper. It is decompofed by lime, manganefe, and iron; and by all the acids, except vinegar, fedative falt, and fixed air.

It has no effect on calcined mercury, but with red precipitate produces fome fmall needle-fhaped cryftals.

The calx of filver precipitated by an alkali is fparingly foluble in this acid, forming with it pellucid, cubic cryftals, difficult to exficcate, eafily foluble in water, but infoluble in alcohol, fwelling and becoming black in the fire, with a difagreeable fmell, eafily decompofed by the acids, particularly by the muriatic, fcarcely fo by the vitriolic, and infoluble in vinegar. This folution is rendered turbid by all the metals, but copper precipitates the filver the beft.

It's affinities according to thefe two chemifts.

Arvidfon and Oehrn have determined it's affinities to be in the following order:

Barytes	Lead
Potafh	Tin
Soda	Cobalt
Lime	Copper
Magnefia	Nickel
Ammonia	Bifmuth
Zinc	Silver
Manganefe	Alum
Iron	The effential oils and water.

This acid, although it may appear weak, has, according to these two chemists, the advantage of the acetous, boracic, vitriolic, fuming nitrous, and carbonic acids; on some occasions, it is even superior to the arsenical acid, from which it takes nickel and cobalt.

It could not have been supposed that a degree of heat incapable of destroying this acid is able to change this order of affinities; yet the boracic acid at the boiling heat disengages it, which from this circumstance becomes the differential term of the wet and dry way.

Bergman had placed the affinities of the formic acid in the following order: According to Bergman.

Moist way.	Calx of lead	Dry way.
———	——— tin	———
Barytes	——— copper	Barytes
Potash	——— bismuth	Potash
Soda	——— antimony	Soda
Ammonia	——— arsenic	Lime
Lime	——— mercury	Magnesia
Magnesia	——— silver	Metallic calces
Argile	——— gold	Ammonia
Calx of zinc	——— platina	Argile.
——— iron	——— water	
——— manganese	——— alcohol	
——— cobalt	——— phlogiston	
——— nickel		

It appears therefore that Bergman had placed in his table of chemical affinities arsenic after nickel, antimony after bismuth, and platina after silver; but Arvidson and Oehrn found that arsenic was not attacked by the formic acid, that it's calx was only dissolved as in water; that this acid did not contract any union either with antimony or it's calx; and that the small portion of the precipitate of platina, which this acid dissolved at first, was very soon

depofited, particularly by the aid of heat, in the form of a ferruginous powder.

The formic miſtaken for other acids.

The formic miſtaken for other acids.

Margraaf, and ſeveral other chemiſts who have examined the formic acid, looked upon it to have a great analogy to vinegar, "but," exclaims Morveau, "what do they mean by this? that it has nearly the ſame degree of acidity; that it is ſuſceptible of the ſame degree of concentration; that it is decompoſed in the ſame manner by fire; that it can be ſubſtituted for it in economical or medicinal purpoſes, when only an acid of the ſame intenſity is required? In theſe ſenſes all ſubſtances are analogous to each other, for there is no one in nature, that is diſtinguiſhed from *all* the others by *all* it's properties."

It differs from vinegar, 1ſt. by it's ſpecific gravity, for although it approaches vinegar very near in this reſpect, yet it is ſaturated by a ſmaller quantity of an alkali or an earth. 2d. By it's effects with alkalis; ſince it forms with ammonia a deliqueſcent cryſtalline ſalt; with lime, one that forms irregular cubes, and with magneſia, a ſalt that is difficult of ſolution. 3d. By it's metallic ſalts; for example, it forms with copper, not a dark green, but a blue cubic ſalt; with nickel, not a cubic but a cluſtered ſalt; and with zinc, one that is cubic and not ſcaly: it neither diſſolves the calx of mercury nor of antimony, but vitrifies the former: finally, it diſſolves the calx of iron, and likewiſe forms cryſtals with iron itſelf; which vinegar, according to Arvidſon, does not. 4th. By it's affinities, for it always detaches vinegar from it's union, and even takes nickel and cobalt from the acid of arſenic.

According to Thouvenel, the formic acid is very analogous to the phoſphoric, or, as he calls it, the microcoſmic acid; but he has not given any account in which

properties this analogy confifts. On comparing thefe two acids together, there is not perhaps two others which have fo diftant a refemblance. The firft fuftains a vitrifying heat, whilft the other is deftroyed by the heat of diftillation; the one forms with lime an infoluble falt; the other a falt that cryftallizes and is foluble, &c.

Lifter affirmed that he had extracted a fimilar acid from wafps and bees; but Arvidfon and Oehrn were not able to obtain it from thefe infects, and at prefent the ant is the only animal in which it has been found.

The formic acid is therefore an acid *fui generis*, differing in it's bafis, but poffeffing the fame acidifying principle as the others, viz. vital air. "There needs no other proof of this," fays Morveau, "than the effervefcence produced by the refiduum of the diftillation of formiat of potafh. Margraaf, who obferved this phenomenon the firft, before the theory of gafes was known, was aftonifhed, with reafon, at the difappearance of the acid of this falt; which had only left a falt with alkaline properties, and which effervefced with it's own acid. What paffes in this operation is now known; if the acid be only weakly attached to it's bafis, it is difengaged; if the union be more intimate, a ftronger degree of heat is neceffary, which deftroys by it's violence the compofition even of the acid; and the acidifying principle, the air being detached from it's bonds, is converted into carbonic acid gas, which uniting with the alkali, renders it effervefcent."

According to Morveau, this acid contains phlogifton, which is lefs adherent to it than to vinegar, fince this laft readily diffolves the calx of mercury, whilft according to Arvidfon and Oehrn the formic acid reduces it; *i. e.* is obliged to yield it's phlogifton to the more powerful affinity of the mercurial earth; it alfo yields it to the dephlogifticated muriatic acid.

Thefe phenomena are better explained by the new chemiftry.

Fourcroy's definition of t.

The definition which Fourcroy has given of the acid is the following:

"The formic acid is extracted from ants either by diftillation or expreffion with water; reddens blue flowers in the living infects; difengages itfelf from them in the form of a very ftrong odorous vapour, analogous in it's odour to that of mufk; deftroys animals under this gafeous form; is capable of ferving economical purpofes like vinegar; is decompofed by a great heat; takes oxygen from oxygenated muriatic acid; is oftentimes ftronger than fulphuric acid; and forms falts with alkalies and earths, which are cryftallizable and not deliquefcent."

Encycloped. Méthodique. Chemie. tom. 1. p. 1. artic. Acide Formicin, ou des Fourmis, p. 60.—Macquer's Chym. Wœrterbuch, von Leonhardi, tom. 1. p. 179. art. Ameifenfaure.—Margraaf's Chymifche Schriften, Berlin. 1768.—Rouelle, in the Journal de Phyfique, Mars. 1773.—Abhandlung von der Ameifenfaure, von Hern Arvidfon and Oehrn in Baldinger's Neues Magazin fur Aerzte. 2 b.—Philofophie Chimique par Fourcroy.—Bergman's Opufcul. iii. tab. 2. No. 20.

LACTIC ACID.

Lactic acid.

Although the acidity of milk or whey, from the great eafe with which they undergo the acetous fermentation, was known to the ancients, yet it was not difcovered to be owing to a peculiar acid, until the experiments of Scheele firft made it known. Previous to Scheele's experiments, however, it appears, that Lichtenftein had obferved this acid when fpeaking of the *acid fugar of milk*, which he

Difcovered by Scheele

says, "is a sugar of milk rendered impure by the acid of the whey, of which acid it may be deprived by repeatedly extracting from it alcohol or pure water."

Scheele, however, proved it to be an acid, and is therefore entitled to the discovery, for it is to him we are indebted for our knowledge of it's characters and properties.

Milk, if left to itself to become sour, receives the greatest degree of acidity it is capable of in about fourteen days, which is the time this acid should be obtained.

Scheele, in order to obtain this acid pure, and knowing it impossible to effect this by a simple distillation, from it's not being able to bear the heat necessary to raise it, and that in a less degree it only afforded a very small portion of a very weak vinegar, had recourse to more industrious means to obtain this separation.

His method of obtaining it.

Being assured of the presence of an animal earth in whey, from the precipitate which lime water or caustic volatile alkali occasions in it, the whey evaporated to one half, and filtered to separate a remaining portion of caseous matter, had afforded him a precipitate of tartar on adding the tartarous acid; he concluded from this, that the whey contained alkali, or rather an essential salt, of which the alkali made a part; and this observation was further verified by the whey, reduced to a coal, having afforded him by lixiviation some alkali mixed with a little muriat of potash instead of it's salt, which was destroyed by combustion. In short, he knew that it contained sugar of milk and a little mucilage; it was, therefore, necessary to isolate all these substances by processes incapable of altering it, and the success will be seen to have answered his wishes.

He first reduced the whey to $\frac{1}{8}$ by evaporation, filtered it, and there remained no more caseous parts.

He then ſaturated the liquor with lime water, and the animal earth was precipitated. This liquor having been filtered and diluted with three times as much water, he added, drop by drop, ſome ſaccharine acid to it to precipitate all the lime, and he aſſured himſelf, by the addition of a little lime water, that there remained no more ſaccharine acid.

He then evaporated the liquor to the conſiſtence of honey, and the thicker acid was rediſſolved in well rectified alcohol. The ſugar of milk, and all the other ſubſtances foreign to the acid, which had not been diſſolved by the ſpirits of wine, remained on the filter. At laſt, after having returned a little water to the acid held in ſolution by the alcohol, he diſtilled this laſt, and found in the retort ſome very pure lactic acid.

Objected to by Parmentier.

Parmentier and Deyeux ſay, that this proceſs of Scheele to procure this acid very pure does not merit any confidence, as the complicated operation he employed ſo totally changes it's nature, that it preſents none of the properties that belong to it; that it is rather a new acid that is formed, than the ſeparation of an acid that previouſly exiſted. It is procured by congelation; but the acid obtained is always impure.

Scheele found that this acid afforded no cryſtals, even when reduced to the conſiſtence of an extract, and when puſhed to dryneſs it deliqueſces.

It's properties.

On diſtillation, at firſt, ſome phlegm ariſes, then a weak acid reſembling ſpirit of tartar, afterward an empyreumatic oil, and a new portion of the ſame ſpirit, ſome mephitic gas and inflammable air. In the retort a little coaly matter remains. It gives tokens of the preſence of a little vitriolic acid, for if digeſted on lead, a light white ſediment is formed in the ſolution, which is vitriol of lead.

With fixed vegetable alkali it forms a deliquefcent falt (galacticum potaffinum of Bergman) which is foluble in alcohol.

With mineral alkali, a falt (galacticum natratum) which does not cryftallize, but is foluble in alcohol.

With volatile alkali, a deliquefcent falt (galacticum ammoniatum) which, on expofure to the fire, lofes it's ammonia before it's acid.

With barytes, lime, and alumine, it forms deliquefcent falts; on the contrary, with magnefia, it gave fome cryftals which, however, deliquefced afterward.

It has no action, either in digeftion or at the boiling point, on bifmuth, cobalt, antimony, tin, mercury, filver and gold.

The lactic acid which has repofed on tin precipitated gold from aqua regia, of a black colour; it gave with iron a brown folution; with copper, a blue folution, which became green, and afterward changed to a dark brown; with lead, a harfh fweet folution like vitriol of lead; thefe are not cryftallizable; with lime, however, it formed a cryftallizable falt. As to the reft, Scheele remarks, that it difengages vinegar from the terra foliata tartari; and Bergman has given it a place between the formic acid and vinegar.

When Scheele had difcovered the malic acid, he found the only difference between thefe acids to be, that the lactat of lime was foluble in alcohol, and malat of lime infoluble.

It's affinities, according to Bergman.

According to Bergman, it's affinities are to other bodies in the following order, in the *moift way*: Barytes, vegetable alkali, mineral alkali, ammonia, calcareous earth, magnefia, alumine, calx of zinc, iron, manganefe, cobalt, nickel, lead, tin, copper, bifmuth, antimony, arfenic, mercury, filver, gold, phlogifton, and platina.

In the *dry way*. Barytes, potafh, and foda, calcareous

earth, magnefia, the calces of metals, ammonia, and alumine.

Opinion of Morveau.

From thefe experiments and obfervations, it appears to Morveau, that whey is of itfelf, and independent of the falts it contains, an acid of a peculiar nature. Scheele feems to believe that it does not afford a perfect vinegar; but this is only becaufe it wants the matter which produces the fpirit in fermentation; Morveau has no doubt but that one part of it becomes vinegar, and he fupports this opinion from thefe two facts:

1. If a bottle filled with milk be inverted in the fame liquor, and be expofed to a degree of heat fomewhat greater than that of fummer, it furnifhes mephitic gas, which, at the end of two or three days, is found to have converted the milk into curd. This proves that milk may undergo a complete fermentation without fhowing any evident traces of alcohol.

2. If fix fpoonfuls of good alcohol be added to about three pints of milk, and be expofed to a heat, well corked, giving vent from time to time to the gas of fermentation, the milk, at the end of one month, will be found converted into very good vinegar, which, after filtration, may be preferved in bottles. Thefe two facts prove, according to Morveau, that the galactic acid, as he calls it, is the product of the acetous fermentation, and that if the milk was richer in fpirit, the product of the various fermentations would be more fenfible; but this does not prove the abfolute identity of the galactic acid and vinegar; and Scheele informs us, that the lactic acid does not cryftallize either with lime or foda; that it cryftallizes with magnefia; that in diftillation, it lets go the volatile alkali, and that it takes potafh from vinegar, which announce an acid different from vinegar.

With refpect to Morveau's ideas on this acid, he looks upon it as the production of a real fermentation, in proof

of which he remarks, that milk is retarded from becoming ſour after having been boiled, or diluted with a large quantity of water. In theſe two caſes, ſo contrary in appearance, Morveau aſſerts, that the affinity of the decompoſing ſubſtance is equally prevented on the one part; by the abſtraction of a portion of the fluid neceſſary to the inteſtine motion ; on the other part, by the exceſs of the ſame fluid, which occaſions a too great diſperſion of the parts, which is very conformable to the progreſs of every fermentation.

No ſpecies of fermentation is ſufficiently characterized by the nature of the produce, which is an acid. It is not that the milk is not alſo ſuſceptible of the ſpirituous fermentation, but it is probable, that in this particular caſe, the paſſage from the firſt to the ſecond fermentation is ſo rapid as not to be ſenſible, when the too eaſy diſunion of all the parts of the maſs is not oppoſed by a mechanical motion. Whether this is the truth or not, it is, according to Morveau, impoſſible not to acknowledge a fermentation abſolutely analogous to that which converts wine into vinegar ; the agent, the manner of acting, the effects are all ſimilar. This agent is the air, it acts by the affinity it exerciſes upon that of the principles of the milk, which ought to enter into the compoſition of it's acid ; this ſubſtance fixes the air, which we know to be the common acidifying principle, and from their combination, the acid whey or galactic acid ariſes.

Thus, Morveau affirms, that the whey did not exiſt in the milk, ſuch as it is *found after the ſeparation of the other* conſtituent parts.

Scheele's Chemical Eſſays, 1786—Encyclop. Méth. tom. I. p. 1. Chimie art. Acide Galactique. p. 63.—Macquer's Wœrterbuch von Leonhardi, neue Zuſatze und Anmerkungen zu 1 ter. b. p. 753. art. Milchſaure, Molkenſaure Leipſig. 1792.

Saccho-lactic acid.

Saccho-lactic acid.—On treating of the fugar of milk, when diftilled with the nitrous acid; it was remarked, that a large quantity of a white powdery fubftance was mixed with the oxalic acid, which rendered the folution turbid; and which it was neceffary to feparate from the liquor by filtration, before the cryftals of the oxalic acid could be obtained.

Difcovered by Scheele.

This fubftance was difcovered by Scheele to be a peculiar acid, to which the name of faccho-lactic acid has been given, or the acid of the fugar of milk.

The chemifts who before Scheele had undertaken the analyfis of the fugar of milk, had not even fufpected the exiftence of fuch an acid, and although it was admitted by the illuftrious Bergman as an acid *fui generis*, to which he has given the name of acidum galacto-faccharinum: Hermbftadt and Weftrumb have looked upon it as a calcareous faccharite with an excefs of acid, or an oxalat of lime. Indeed, from it's external appearance, Scheele himfelf had at firft conceived the fame idea, that it might be an oxalat of lime; particularly when he confidered, that as a little of this earth always exifts in milk, it might poffibly be prefent in the fugar of milk; but experience foon convinced him to the contrary; for on pouring a little faccharine acid into a folution of the fugar of milk, no precipitation took place.

Miftaken for an oxalat of lime.

According, however, to Morveau, this obfervation alone appears not to merit all the confidence Scheele gave it; efpecially, if, as he fuppofes, the oxalic acid exifts already formed in the fugar of milk: for it is evident to this chemift, that the addition of a new portion of the fame acid, not being able to form a different combination; nor to unite to the falt, except to give it an excefs of acid, would only favour it's folution, inftead of producing a precipitation. If, however, the fugar of milk, as Morveau is of opinion, as well as common fugar, does

not contain the oxalic acid ready formed, the obſervation is more concluſive, although not deciſive; ſince it is poſſible that the union of the lime with the other conſtituent parts of the ſugar of milk is ſuch, as not to be deſtroyed even by the oxalic acid itſelf.

The other proofs alleged by Scheele are the following, and appear to be deciſive of it's being a peculiar acid.

Proofs of it's being a peculiar acid.

1ſt. Having caſt ſome of this earthy ſubſtance into a red hot crucible, it burned like oil, and ſcarcely left any aſhes; whereas, according to Morveau, the oxalat of lime left a reſiduum of nearly half it's weight.

2d. It diſſolved in 60 parts of boiling water; one-fourth of the portion diſſolved cryſtallizes on cooling, and the remaining three-fourths are left in the cold water, *i. e.* one part of this earth is 80 of water: now it is certain that the oxalat of lime is much leſs ſoluble, and Bergman has obſerved, that it was not more ſo by the intervention of ſugar.

3d. 240 grains of this purified ſubſtance in cryſtals being rediſſolved in 14400 grains of boiling diſtilled water the filtered ſolution manifeſted an acid ſavour, reddened the infuſion of litmus, and efferveſced with chalk; but none of theſe properties belong to the oxalat of lime.

4th. Scheele diſtilled 120 grains of it in a retort, it melted very readily, became black, foamed conſiderably, and in the neck of the retort a brown ſalt was ſublimed, which ſmelled like a mixture of benzoin and amber; and there remained 11 grains of coal. The receiver contained a brown liquor without any oily appearance; it had the ſame taſte as the ſublimed ſalt, in ſhort, it contained ſome of it, which ſeparated by a gentle evaporation. The ſublimate weighed 35 grains, it had an acid ſavour, diſ-

ſolved readily in alcohol, but with more difficulty in water, and in the fire burned with a flame.

5th. Concentrated vitriolic acid diſtilled on this ſalt became black, foamed, and entirely deſtroyed it.

6th. This purified ſalt thrown in ſmall quantities into a hot ſolution of potaſh, until there was no longer any effervefcence, ſoon produced a quantity of ſmall cryſtals. Theſe were perfectly neutral; they only required for ſolution eight times their weight of boiling water, and when the water was cool, the greater part of them ſeparated from it again. This ſubſtance did the ſame with ſoda, but only five parts of boiling water were ſufficient to diſſolve a portion of it.

7th. When ſaturated with ammonia, it afforded an ammoniacal ſalt, which after a gentle calcination was found acid on diſtillation; ammonia came over, which precipitated lime water.

8th. With earths it formed inſoluble ſalts. It's aqueous ſolution decompoſed the muriat of barytes, calcareous nitre, &c. but not vitriolated lime. Theſe ſolutions were in turn decompoſed by the ſalt reſulting from the union of this ſubſtance with alkali.

9th. Finally, it acted the ſame with metallic calces as with earths; it alſo decompoſed ſeveral metallic ſolutions, but not thoſe of copper, iron, zinc, and magneſia in the vitriolic acid, nor thoſe of tin and mercury in the muriatic acid.

Such are the properties by which Scheele ſupported his opinion of it's being a new acid, different from all the other known acids, particularly the oxalic; which opinion is now well-eſtabliſhed: for, according to Morveau, it has neither the taſte, form, ſolubility, nor power of the oxalic acid; nor is it the oxalat of lime, for this is a neutral ſalt without taſte, and abſolutely inſoluble; nor is it a calcareous oxalat with an exceſs of acid, for in conſe-

quence of this excefs, it ought to act like this acid, when free, *i. e.* decompofe vitriolated lime, vitriols of copper, iron, zinc, manganefe, and the muriat of quickfilver; it ought more particularly to quit it's earthy bafis, when decompofed and re olved into it's aeriform elements, whether by fire, or ftill better by the vitriolic acid; with the alkalies it ought to produce two diftinct falts, different by their folubility, becaufe it is well known that the alkalies cannot deprive this acid of lime, and we have feen that nothing of this fort took place.

Hermbftadt.

Having given an account of Scheele's experiments; it will be now neceffary to take a view of thofe of Hermbftadt in oppofition to the former.

Experiment and conclufion in oppofition to Scheele.

It has been faid, when treating of the fugar of milk, that Hermbftadt as well as Scheele, had obtained an earthy fubftance from the fugar of milk, independent of the oxalic acid, which he obtained in cryftals; on treating that falt with nitrous acid, 1290 grains of fugar of milk afforded this chemift 720 grains of this fubftance when edulcorated and dried, which exceeds what Scheele obtained by one third, which Morveau thinks can only be attributed to a more perfect decompofition of the falt. In his firft memoir Hermbftadt has defcribed this fubftance as compofed of tender flocks, refembling very fmall cryftals of felenite, of an acidulous favour, of which they were not to be deprived by ebullition, and infoluble in water; he added, in his fecond memoir, that this fubftance was a white light earth, rough to the touch, fomewhat fandy, like tartar of lime (tartare calcaire); that it's favour was fomewhat acidulous, but weaker than that of cream of tartar; that it likewife had an earthy favour refembling that of gypfum; that it did not appear foluble in faliva; in fhort, that it had all the appearance of calcareous tartat, or oxalat of lime.

It's infolubility in water was an important article, which Hermbſtadt diſcuſſed again. He found,

1ſt. This *acid* earth, as he calls it, on being digeſted with diſtilled water, very little was diſſolved; yet the acidulous and earthy taſte of the water, and the ſmall reſiduum, ſhowed that ſome had been diſſolved; evaporated and left to repoſe, it left a browniſh ſaline particle, of an acid ſavour like tartar, and which formed a precipitate with lime water.

2d. 140 grains of acid earth burned in a red hot crucible, until there were no longer any vapours, left 80 grains of a coaly reſiduum. This diſſolved in nitrous acid, and filtered, and alkali added, 20 grains of white calcareous earth were precipitated, and there remained on the filter a black powder, which he took for burnt acid.

A little acid earth being expoſed to the flame of a candle, it immediately ſwelled, gave ſuffocating vapours, and ran into a brown matter which taſted like common tartar; when thrown upon the coals in it's fluid ſtate, it burned with a white flame, decrepitated, and left behind a ſlightly inſipid coal.

3d. In order to follow the method of Scheele, he diſtilled ſome of this acid earth in a retort; it melted, filled the receiver with ſubtile vapours; and having raiſed the heat afterwards, and then left it to cool, he found a browniſh ſalt in the neck of the retort, of an acid and empyreumatic ſavour; little ſoluble in water, more ſo in alcohol; which he attributed to an oily matter. In the receiver was a little browniſh liquor, which had all the properties of an aqueous ſolution of the preceding ſalt. The reſiduum was a light coal like that left by ſugar of milk; there were no traces of an alkali, but nitrous acid boiled upon it gave a precipitate of calcareous earth on the addition of an alkali.

4th. Hermbſtadt had alſo ſuppoſed this acid earth to contain a ſuperabundant acid, and to deprive it of it he had triturated 240 grains of it with a ſolution of potaſh, until it no longer effervefced, and the mixture had an alkaline ſavour. The diluted liquor being boiled a few moments gave on cooling an *earthy depoſit*; which edulcorated in hot water, and dried, weighed 330 grains, *i. e.* 90 grains more than at firſt. This increaſe of weight announced it's having united with alkali, which he confirmed by another experiment; for the ſame *earthy depoſit*, put into a red hot crucible, ſoon became black, gave vapours of the odour of burned ſugar of milk, and there remained a brittle ſaline maſs, the ſolution of which afforded an alkaline liquor, and a little earthy precipitate like calcareous earth.

5th. He likewiſe poured ſome volatile alkali to exceſs upon this acid earth; it effervefced, but diſſolved very little; diluted with diſtilled water, and expoſed one hour to a ſand heat, on cooling, a ſaline pellicle formed. The liquor having ſtill the odour of the free alkali, he evaporated it to dryneſs, and found ſmall confuſed cryſtals of a neutral ſalt. He remarks as a fact difficult to explain, that the ſaline or earthy matter had not increaſed in weight; it had not the acid ſavour, obſerved by Scheele, which he attributes to the difference of the proceſs.

Cauſtic volatile alkali, treated in the ſame manner with this acid earth, afforded no ſenſible ſolution or increaſe of weight; after a complete evaporation, the dried ſaline maſs was acid as before; it contained no alkali, ſince an addition of two parts of potaſh diſengaged no ammoniacal odour.

6th. Hermbſtadt obſerved, as well as Scheele, that the ſolution of this acid earth was not rendered turbid by ſaccharine acid.

7th. He again treated this acid earth with vitriolic

acid, in order to convert the calcareous earth he ſuppoſed it to contain into ſulphat of lime. He boiled 40 grains of concentrated vitriolic acid diluted with 48° of diſtilled water on 120 of this ſubſtance, and on leaving it to repoſe, there was a depoſit of ſelenite. The liquor evaporated to one third depoſited a thick black matter on the ſides of the veſſel, which was moſtly decompoſed ſaccharine acid; there afterwards ſeparated, on cooling, ſome cryſtalline flocks of ſelenite, which waſhed and put on the coals gave not the leaſt trace of ſaccharine acid. The reſt of the liquor was pure vitriolic acid.

From theſe experiments, Hermbſtadt concludes, that the acid earth is compoſed of calcareous earth, ſaccharine acid in exceſs, and a fat matter; that it is not a pure acid, as it would be more ſoluble, but an eſſential acid ſalt, of the nature of tartar or ſalt of ſorrel, except inſtead of the alkali, it is the lime which ſerves as a medium of union between theſe principles; that it only differs from the ſugar of milk, becauſe this contains a greater quantity of acid dulcified by the fat part; that when ſugar of milk is treated with the nitrous acid, the ſaccharine acid, united to this fat part, is ſet at liberty, and that the ſurplus remains combined with the calcareous earth; laſtly, that the vitriolic acid has the property not only of depriving the ſaccharine acid of the calcareous earth, but likewiſe of decompoſing it.

Morveau corroborates the opinion of Scheele.

Theſe concluſions, drawn from Hermbſtadt's experiments, have been examined by Morveau, who begins by ſtating, that Hermbſtadt, in order to combat with advantage Scheele's ſyſtem on the *ſaccho-lactic acid*, and, at the ſame time, to confirm the reſults of his firſt analyſis, ought to prove,

1ſt. That the ſubſtance to which Scheele has given that name had a baſis.

2d. That it's acid was the faccharine acid, and had all it's properties: which he had not done.

It appears to Morveau, that with refpect to the calcareous earth which Hermbftadt found, his experiments on this part are more conclufive than the reft; and it is poffible that fugar of milk contains fome of that earth, if not effentially, at leaft accidentally. Scheickel found fome in refined fugar. The fugar of milk which Morveau fubjected to experiment came from Switzerland; it was very white and perfectly cryftallized.

He took fome of the *acid earth* in it's greateft ftate of purity *i. e.* diffolved in boiling water, cryftallized, and then rediffolved; into this he poured a few drops of lime water, to the point of faturation; he then added fome of the fame acid until there was an excefs of it; he then left it to repofe for 24 hours, to be certain that the falt which had formed was held in folution; he then poured fome common faccharine acid into it, and in a few hours there was a very fenfible depofit that obfcured the fides of the glafs, which is ufual with the faccharite of lime produced by precipitation. This proves two facts:

1ft. That it was not the faccharine acid which held the lime in folution, or the addition of the fame acid would have promoted inftead of ftopping the folution; an acid never decompofes falts of it's own fpecies.

2d. That it is impoffible that the acid earth holds calcareous earth, fince this acid earth cannot be collected except at the moment it fwims in the faccharine acid; and it is fhown by this experiment, that this laft acid deprives this acid earth of it's calcareous earth, and forms with it an infoluble falt. Thus, at moft, it would be calcareous faccharite that is mixed accidentally with it, which it could not diffolve. Hence Morveau concludes, that this acid is really the faccho-lactic acid, which is different from the oxalic acid.

Morveau found, that to diffolve fix grains of this acid completely, nearly one ounce of boiling water was neceffary, and that it depofited about 14 in a more cryftallized form on becoming cool: this liquor very fenfibly reddened blue paper; it's fpecific gravity at 12° was 1,0015. It effervefces with the carbonated earths and alkalies, and forms with them neutral falts, which have been called faccholactats by the French chemifts.

As this acid can only be diffolved in fmall quantity, it cannot have any action in a liquid ftate upon the metals; it unites better therefore with their calces, and forms falts with them very little foluble.

Fourcroy's definition of it.

Fourcroy in his Philofophie chimique, has thus defined it. The faccholactic acid is precipitated in the form of a white powder, from the oxalic acid formed by the fugar of milk, and the nitric acid; it is very little fapid, very infoluble, decompofed by means of fire, and affords a fublimed falt of the odour of benzoin; it forms cryftallizable falts with alkalies, that are very little known.

It's affinities according to Bergman.

The order of it's affinities, according to Bergman, is the following:

Moift way.		*Dry way.*
Lime	Alcohol	Lime
Barytes	Phlogifton.	Barytes
Magnefia		Magnefia
Potafh		Potafh
Soda		Soda
Ammonia		Metallic calces
Argile		Ammonia
Metallic calces		Argile.
Water		

This chemift obferves that the order of the earths is very difficult to determine, from the fmall folubility of the falts refulting from their combinations.

That it gives up the calcareous earth to feven acids,

viz. the faccharine, oxalic, vitriolic, tartareous, karabic, phofphoric, and ouretic.

That it decompofes the nitres of filver and mercury, and the nitre and muriat of lead.

That by double affinity it decompofes all the metallic falts, when it is in the ftate of an alkaline neutral falt.

Morveau is of opinion, that this acid is formed of the acidifying principle oxygen, and a radical or acidifiable bafis; and that every thing concurs to indicate, that the fugar of milk contains only the faccholactic radical, which being different from the faccharine radical, conftitutes all the difference between the fugar of milk and common fugar.

Scheelii Opufc. chem. et phyf. T. 11. p. 111.—Hermbftadt's Phyf. und chem. Abhandl. T. 1. p. 301.—Encycloped. Méthod. Tom. 1. Chimie, p. 288 to 293.—Philof. Chimiq. p. 71.

Bombic acid.—It had been mentioned by the Abbè Boiffier de Sauvages, in treating of the difeafe of the filkworm, which the French call *mufcardine*; that on tafting the humour of one of thefe difeafed infects, which he had cut in two, he found it to imprefs on the tongue a very ftrong degree of acidity, but he looked upon it only as the effect of the difeafe, and perfectly foreign to the organization of the infect. Bombic acid.

In 1781, Chauffier being defirous of making a few experiments on filk worms, had bred a certain quantity of them for that purpofe. Several of thefe having efcaped from the paper cafes, got into an adjoining cheft of drawers, where having peaceably fpun their filk, they underwent the other two changes. Having fome time after looked into the drawers, to his great furprife he found feveral leaves of blue paper with red fpots, as if fome acid Difcovered by Chauffier.

had been ſprinkled upon them. This excited his curioſity; and on ſeeing ſeveral of theſe inſects in their butterfly ſtate attached to this paper, he ſuſpected that they might contain ſome acid liquor, which was neceſſary in performing ſome function, and which they ſhed during their metamorphoſis into a butterfly. This ſuſpicion was ſoon verified, for on encloſing a few of them in caſes of this blue paper, when they were about to undergo this change, he obſerved the paper to be moiſtened, and changed in ſpots to a red colour; and hence aroſe the diſcovery of the exiſtence of a diſengaged acid in the ſilk worm, called the bombic acid.

The part of the inſect that ſupplies

Chauſſier, in order to find whence this acid liquor proceeded, examined the viſcera of this inſect, and found that the lymph, which in the caterpillar ſtate circulated in a ſpungy texture, ſituate between the ſkin and the ſtomach, was collected and depoſited by degrees, as the animal was preparing for it's chryſalis ſtate, in a new reſervoir ſituate near the anus; and was formed at the time when the animal, preſſed by the neceſſity of voiding it's reſervoirs of the gummy juice, lays the firſt veſtiges of it's ſilk.

It's colour.

Accumulated in this reſervoir of the chryſalis or riſing butterfly, it is of an amber colour, of a peculiar ſavour, and ſlightly mucous; in ſhort, ſays Chauſſier, "it is a free acid which immediately reddens the blue tinctures of vegetables, unites with efferveſcence to aerated alkalies, diſſolves certain metals; treated on the fire with alcohol, according to the proceſs of Landriani, produces a ſort of æther; is reduced to a gas, and finally, has all the properties characteriſtic of acids.

Method of collecting it from the chryſalis.

Having ſatisfied himſelf reſpecting the origin and ſeat of the acid, Chauſſier was deſirous of finding the beſt method of collecting it; and he firſt began by cutting the chryſalis in two, in order to ſeparate that part which

contained the acid, but as it immediately changed the ſteel to a black colour, and had the inconvenience of making his fingers black as ink, which continued ſeveral days; and beſides, as it would have ſoon become putrid, like all other animal acids extracted by expreſſion, by holding in ſolution ſome mucous parts, this academician made uſe of another proceſs to obtain the liquor. He bruiſed 15 oz. of healthy chryſalides recently drawn from the ſilk-cods, in a glaſs mortar; and by expreſſing them through a linen cloth, obtained 9 oz. of a thick yellowiſh juice, very ſtrongly acid.

The chryſalides which are not drawn from their cods till after the winding of the ſilk, and have been expoſed to the heat of the furnace, or the vapour of boiling water, ſtill afford the ſame liquor.

To deprive this liquor of it's mucous parts, which would not only diminiſh it's diſſolving energy, but diſpoſe it to putrefaction; he added 2 oz. of alcohol to it. The mixture at firſt was warm, but ſoon became clear; and being filtered, the liquor was clear, of a beautiful orange colour, and of an odour approaching that of the ſilk worm or mulberry tree. Into this filtered liquor ſome more alcohol was poured by degrees, and at each time there formed a ſlight white precipitate, which was nothing but a gummy ſubſtance. This was continued until no more precipitate appeared, for which 3 ounces and half were neceſſary.

The different depoſits that remained on the filter weighed one ounce and a half; and the ſurface reſembled an oil of a beautiful orange colour, of the odour of the ſilk worm. This oil was inſoluble in ſpirit of wine, although it coloured it ſomewhat; one part was of a gummy nature, and ſoluble in water, the other part appeared to Chauſſier to be a ſort of animal gluten, intimately united to an earth and a fat oil.

To obtain it pure.

Inſtead of bruiſing the chryſalides they may be ſimply infuſed in alcohol. In a ſhort time the acid unites to the ſpirit, is of a beautiful tranſparent orange colour; and as the acid is more fixed than the ſpirit, by evaporation by a gentle heat a very pure acid is obtained, which concentrated by evaporation in the air, and purified from the mucous matter by repeated filtrations, is no longer ſubject to change.

The acid exiſts in every ſtate of the inſect according to Chauſſier.

Having ſatisfied himſelf of a free acid in the chryſalis, he was deſirous of knowing whether it exiſts wholly formed during all the ages of the inſect, or only on paſſing to the chryſalide ſtate. He had at firſt embraced the latter opinion, founded on this circumſtance, that the diſtillation of 12 oz. of ſilk worms in the fourth age only afforded ſome phlegm, an empyreumatic oil, and volatile alkali; without any evident veſtige of an acid, or even of a gas, that might have announced the decompoſition of the acid. But he received no more on diſtilling the chryſalides themſelves, in which the acid is ſo developed; on the other ſide, the coaly reſidua of both operations, lixiviated in boiling water, furniſhed a neutral ammoniacal ſalt; and even the eggs of the ſilk worm, when digeſted in water mixed with a little alcohol, afforded him ſome feeble but evident marks of acidity.

Hence he thinks he is enabled to conclude, that the acid principle exiſts at all times during the life of the inſect, but in a different manner; in the egg and in the worm it is combined with a glutinous gummy ſubſtance, and it cannot be recognized without precipitating this ſubſtance, which marks it's properties, as by the infuſion of alcohol, whilſt nature performs this operation in the diſeaſe called the *muſcardine*; but in the chryſalis the acid is always free and developed, and immediately ſhows it's acid properties.

Objected to

This concluſion of Chauſſier appears to Morveau to

have ſeveral objections; for example, it is not known what becomes of the acid in the diſtillation, which is found at leaſt in exceſs in the chryſalis; nor is it more eaſy to conceive how this acid ſhould be able to form with the volatile alkali an ammoniacal ſalt, that could reſiſt a diſtilling heat, without even being ſublimed; in ſhort, Morveau is of opinion, that the eggs of the inſect, after their maceration in water and alcohol, may leave ſome traces of an acid, without it's being the ſame as that of the chryſalis. As it has been proved that this laſt is very abundant and manifeſt, he is inclined to believe, that before this metamorphoſis, the animal contains only the acidifiable baſe, which afterward paſſes to a ſtate of perfect acid, by combining with the acidifying vital air, by means of ſome functions peculiar to the new organization of the inſect. by Morveau.

This acid attacks iron, lead, and copper, with which it forms, according to the French nomenclature, bombiats, and in the definition of it given by Fourcroy, it is ſaid to undergo a ſpontaneous decompoſition, affording the pruſſic acid by diſtillation and nitric acid, but unknown at preſent in it's combinations. It's action on the metals.

Mém. ſur un Acide particulier découvert dans le ver-à-ſoie, avec des obſervations ſur l'origine, le ſiege de cet acide, &c. par M. Chauſſier, Nouv. Mém. de l'Acad. de Dijon, acc. ſem. 1783, p. 70.—Encycloped. Méthod. art. Chimie, T. 1. p. 410.

Lithic Acid. For the diſcovery of an acid in the calculus of the bladder, we are indebted to the labours of Scheele and Bergman. It is called by Morveau, in the Encyclop. Méth. the lithic acid, from λιθιασις or λιθος, which chemiſts and phyſicians have made uſe of as a radical Lithic acid

word in their account of the calculus. By ſome chemiſts it is called the uric acid.

It's properties. The lithic acid is a body compoſed of ſmall needles, cloſely compreſſed together, forming very denſe laminæ, ſuſceptible of a poliſh like marble. It is of the colour of wood, is nearly inſipid, and weakly reddens the blues of vegetables. It is inſoluble in cold water, but ſoluble in more than 1000 times it's weight of boiling water; it cryſtallizes on cooling. It is ſoluble in the nitric acid when a little concentrated, which gives it a roſe or pink colour; this is communicated to the ſkin, and when evaporated, a roſe coloured deliqueſcent reſiduum remains. It is inſoluble in the ſulphuric and muriatic acids. It is ſoluble in cauſtic vegetable and mineral alkalis, and may be precipitated from them by the weakeſt acid, even by the carbonic: hence it is inſoluble in alkaline carbonat, and is the weakeſt of all acids, which diſtinguiſhes it from every other.

On diſtillation, it is in part decompoſed, affording the carbonat of ammonia in ſmall quantity, and the pruſſic acid, and is in part ſublimed into an acid ſublimate.

It unites to earths, metallic acids, alkalis, forming with them peculiar neutral ſalts, called lithiats of ammonia, of lime, of copperas; but it appears to prefer the alkalis to the earths.

Obſerved by Leuwenhoeck. Although Scheele may be looked upon as the diſcoverer of this acid, yet Leuwenhoeck had obſerved, before him, the cryſtalline depoſite which took place in water in which a calcined veſical calculus had been boiled; but he had no idea of it's being an acid.

Where found. The lithic acid is found to compoſe the greater part of human urinary calculi, as well as the chalkſtones formed in the gout. Sometimes it forms only the central part of the calculus, and is covered with earthy phoſphats; at other times it is depoſited upon a nucleus of

oxalat of lime. It has not at present been found, according to Fourcroy, in other animals. It exists in all human urines, and is precipitated from them in the form of red sand, on cooling; it is more abundant after acute diseases. It is this acid, according to Fourcroy, that forms the critical deposite of urines; it is most often found forming gravel in the kidnies. It is dissolved on being suspended in a ley of very pure potash, greatly diluted with water, which may be injected into the bladder. It appears to be naturally united in urinary calkali with a coloured animal substance, which would seem to be uree, but in very small quantity. In the chalkstone it is united with soda; and on distillation this acid is decomposed, and yields the usual products of other animal substances, viz. a fetid alkaline liquor, a heavy fetid oil, volatile alkali, and a spongy coal; this last, on incineration, fuses into a white salt that does not deliquesce, is intirely soluble in water, is alkaline, and when saturated with nitrous acid, gives rhomboidal crystals; hence it is soda, the other part of the chalkstone.

It had been suspected by Fourcroy, that this acid was nothing but a modification of another acid; and from a late experiment of Brugnatelli, this suspicion was true. He found that the lithic acid was converted into the oxalic acid with astonishing rapidity, on suffering it to come into contact for a few minutes with oxygenated muriatic acid gas; this experiment has been repeated by Fourcroy, and confirmed. He placed a little powdered uric calculus in a tube of glass, moistened it, and on passing some oxygenated muriatic acid gas through it, the conversion immediately took place. Conversion into oxalic acid.

Leonhardi's Wœrterb. v. 5. p. 238. art. Blasensteinesaure.—Fourcroy's Elémens de Ch. T. 4. art. Acide Li-

thique. 1791.—Ency. Méth. art. Acide Lithiasique. Tom. 1. p. 1, 410.—Annal de Chim. No. 95. p. 184, 216.

Amniotic acid.

Amniotic acid. This acid was first discovered in the liquor amnii of the cow, by Buniva and Vauquelin. The small quantity they were able to procure prevented them from extending their experiments upon it, or from ascertaining the quantity of it's component parts; but the investigation was sufficient to convince them of it's being a peculiar acid.

It's properties.

The amniotic acid is a white, shining, concrete substance; it's savour is very slightly acid.

It changes the tincture of litmus to a red colour.

It is very little soluble in cold water, much more so in boiling water, from which it separates on cooling, in the form of needles, several centimetres in length.

It readily combines with caustic alkalis, which render it very soluble in water; the other acids separate it from it's saline combinations, in the form of a white crystalline powder; it does not decompose alkaline carbonates, except by means of heat; it produces no change in the aqueous solution of alkaline earths, or in the nitric solutions of silver, lead, or mercury.

Exposed to the fire, it swells and emits an ammoniacal odour, evidently mixed with prussic acid; a large volume of coal is left behind.

It's relation with other acids.

It would appear at first to have some relation to the saccholactic and uric acids; but this is soon found to be only externally, for the saccholactic acid, on distillation, affords no ammonia; the uric acid, indeed, gives both ammonia and the prussic acid, on exposure to the fire, but it is not so soluble in hot water, does not crystallize into long, white, and shining needles, and more particularly, is not soluble in boiling alcohol, like the amniotic acid.

Des Propriétés de l'acide contenu dans l'eau de l'amnios de vache, appellée *acide amniotique*, dans un mémoire ſur l'eau de l'amnios, &c. par les Cit. Buniva et Vauquelin, An. de Ch. N° 99. p. 279. An. 8, or 1800.

Acid of phoſphorus.—This appellation has been given by chemiſts to this acid, becauſe it was firſt obtained by combuſtion from an inflammable ſubſtance called phoſphorus, which, when pure, is a white tranſparent body, reſembling wax. It is ſometimes cryſtallized and very fuſible. Phoſphorus undergoes two ſpecies of combuſtion. 1ſt. If it be expoſed to the common air of the atmoſphere at the loweſt temperature, even a few degrees below zero, during the day a white ſmoke or vapour is ſeen to ſurround it; if during the night, this vapour appears in the form of a greeniſh white waving light; and in perfect darkneſs, the luminous rays are ſo expanded as only to diſappear at ſome diſtance from the phoſphorus. This luminous vapour is unaccompanied by any ſenſible heat, and does not communicate flame to other combuſtible bodies, but continues to burn and emit light to the laſt atom. This is called the ſlow combuſtion of phoſphorus, and if it be made in an apparatus under a glaſs bell, where the air can be ſlowly renewed by lateral apertures, the acid which is formed, and is diſſolved by the humidity of the air it attracts, is the *~~phoſphoric~~ acid.* 2d. If the temperature in which the phoſphorus is expoſed to common air be raiſed above 40 degrees, or even ſomewhat lower, this ſlow combuſtion ſoon gives place to a rapid combuſtion, a deflagration takes place, accompanied by an aſperſion of numberleſs flaſhes, and very vivid luminous decrepitations; the fuſion is complete, and the heat very ardent that ariſes from it, and the product is the *phoſphoric acid.* This rapid combuſtion is, however, more complete in oxygen gas. Phoſphorus when plunged into

Phoſphorus undergoes two kinds of combuſtion.

this gas, does not burn in the cold, but if when melted it be placed in contaſt with it, it immediately inflames, and the light is ſo ſtrong as to be inſupportable to the eye; and ſo great is the quantity of heat, that according to Lavoiſier and Laplace, one pound of oxygen employed in the combuſtion of this body furniſhes a quantity of heat, capable of melting 66 lb. 10 oz. 5 drachms and 24 grains of ice at zero. This phoſphorus abſorbs once and a half it's weight of oxygen, and is converted into white, ſnowy, cryſtalline flocks, which are the acid. If this phoſphorus thus melted be burnt at the bottom of water by communicating oxygen to it, the acid is diſſolved and puts on a liquid form.

It's purification. Since phoſphorus, when firſt made by artificial means, is not in it's pure ſtate, methods have been diſcovered to rid it of it's impurities. Some recommended the rectifying of it by diſtillation, it was put into a ſmall glaſs retort, to which a receiver half filled with water was applied, and a gentle heat forced over the phoſphorus; but whatever precaution was uſed, a part of the phoſphorus is always loſt by being converted into acid. Another method is, to melt it in hot water a little below ebullition; it is then poured into cold water, taking care not to let it come into contact with the air, as miſchief might enſue from it's inflammation; then cut in pieces, put into tubes and liquified again in hot water, and when cold taken out; by this means the impurities being lighter than the phoſphorus, ſeparate. A third method is to put the phoſphorus into ſome chamois leather, which is to be dipped in boiling water till the phoſphorus is melted; it is then to be preſſed through the leather in the manner quickſilver is purified; but the leather can be employed only once, as it colours the phoſphorus the ſecond time; this method was recommended by Pelletier. It is then put into a long-necked glaſs tunnel, which is cloſed at the ſmaller end by a piece of

wood or cork, filled with water and placed in boiling water; during fusion it takes the form of the tunnel; it is afterwards plunged into cold water, and when fixed, the phosphorus is thrust out by a bit of wood. It is preserved in water, although after a certain time it loses it's transparency, is covered with a white powder, and the water becomes acid. The red impurity observed to attend phosphorus, and which is of all shades to a black, arises from it's union with more or less charcoal, according to Proust, and not from iron, as Nicolas supposed.

Fourcroy found the specific gravity of phosphorus to be to water as 2,0332 to 1,0000. It's savour is somewhat sharp and disagreeable, it has a garlic smell, crystallizes either in the form of needles or micaceous laminæ, or lengthened octoedrons, presenting a great variety. It is very susceptible of heat. At 25° of Reaumur, it is soft and ductile; at 32° it melts, runs, and is transparent, like a white oil; on becoming cold by degrees, it crystallizes; at 76° it is reduced to vapours; at 86° it begins to collect in drops at the mouth of the retort, which has been heated by water. Heated without water, in a stone retort, it boils at 230°, the drops following each other very quick at the mouth.

According to Spallanzani, it does not begin to burn below 5° of Reaumur in common air; and in pure oxygen gas, it burns and produces light only at 22°.

The reason of it's burning sooner in common air than in oxygen gas, arises from it's solution by the azot of the first, which becomes saturated with it; it then burns in oxygen gas; hence in pure oxygen gas alone, no phosphorous acid can be obtained.

Phosphorus being thus procured in it's pure state, the next object is to obtain the acid from it. In the articles *urine* and *bones* it was observed, that this acid might be obtained from both, although the preference was given to

the method of Scheele; but the tedioufnefs of the operation when any great quantity of phofphoric acid is wanted for medical or other purpofes, and the admixture of foreign matters, and other great obftacles againft procuring it in a ftate of purity, independent of the expenfe, oblige the apothecary, who wifhes to procure feveral pounds of it in a fhort time, to relinquifh the attempt of decompofing bones, and to endeavour to oxygenate ready-prepared phofphorus. For this purpofe there are three methods, either by the combuftion of phofphorus, it's gradual oxygenation by expofure to the air, or finally, it's treatment with nitric acid.

Three methods of obtaining the acid from phofphorus.

By combuftion.

1ft. The firft method of obtaining this acid, *i. e.* by the combuftion of phofphorus in a proper apparatus, was recommended by the late Pelletier and profeffor Tromfdorf, and is a good way of obtaining it in a ftate of confiderable purity. This mode, however, cannot be conveniently practifed by every body, fince, according to Pelletier, it requires a very complicated apparatus; befides the combuftion of phofphorus is ill adapted for the fpeedy preparation of large quantities of the acid, fo that, upon the whole, it cannot be recommended as a method to be univerfally adopted by all.

Slow oxygenation.

2d. The fecond method, *i. e.* by the flow fpontaneous oxygenation of phofphorus, cofts very little trouble, not more than that of frequently examining the temperature of the place in which the phofphorus is left to liquefy. It is, however, neceffary, to be cautious not to expofe too large quantities of phofphorus to be oxygenated at once, nor to fuffer the pieces of phofphorus to come into contact with each other; for, according to Suerfen, it has happened to him more than once, that having placed about one ounce of phofphorus in a glafs funnel, in a cellar, it took fire at the temperature of 50 degrees of Fahrenheit. The phofphorous acid thus obtained may

afterward be converted into phoſphoric acid by diſtillation, according to the method of Buckholtz. Though phoſphoric acid may thus be obtained in a very pure and concentrated ſtate, this method is, however, not calculated to become a general rule of practice, for it requires ſtill more time than the firſt method, or the combuſtion of the phoſphorus, independent of the danger of ſpontaneous inflammation.

3d. The third method, *i. e.* by the nitric acid, is looked upon as preferable to the others, for it not only procures whatever quantity is wanted, with certainty, in a very ſhort ſpace of time, but without much expenſe, ſcarcely any trouble, and without any hazard of loſs. This is the method made uſe of by Suerſen, an ingenious apothecary, at Keil, by which he has been enabled to procure, in the ſpace of a few hours, as large a quantity of pure and concentrated phoſphoric acid as he formerly could ſcarcely prepare in a week, or even a fortnight, and that not without a great deal of labour and expenſe; hence it muſt be of great uſe to the practical chemiſt. By nitric acid.

Although in the oxygenation of phoſphorus by the nitric acid, according to profeſſor Tromſdorf, caution is neceſſary, yet it need not be carried to that extent which he aſſerts. If, for example, highly concentrated nitric acid be poured upon a conſiderable quantity of phoſphorus, and this mixture be afterwards expoſed to a violent degree of heat in the ſand bath, an inflammation of the phoſphorus will almoſt unavoidably be the conſequence, as the action of the large maſs of phoſphorus upon the nitric acid being too vehement, a conſiderable part of the former is impelled toward the ſurface, where coming into contact with the atmoſpherical air, an inflammation is produced with ſuch an extrication of heat and air, as violently to break in pieces the veſſels in which the diſtillation is performed. The ſame circumſtance will like-

wife happen, if, according to the directions of Hermbſtadt, 4 ounces of fuming nitrous acid diluted with 18 ounces of water, be poured upon 1 ounce of phoſphorus in a retort, and the mixture be diſtilled in a ſand bath. In this caſe, at firſt, no action of the phoſphorus upon the acid is perceptible; but in the progreſs of the diſtillation, as the nitrous acid becomes more and more concentrated, it's action is ſo inſtantaneous as to impel the phoſphorus with violence to the ſurface, where it immedidiately takes fire, and the loſs of the retort with all it's contents is the conſequence.

As, therefore, it is extremely difficult to obtain phoſphoric acid in this manner, and in general, to perform the operation by means of the ſand bath, the beſt is to follow Lavoiſier's method, viz. to pour the nitrous acid into a tubulated retort, and gradually to introduce the phoſphorus by ſingle drops at a time. By following this method, with ſome variation, a conſiderable quantity of phoſphoric acid may be prepared with the utmoſt ſecurity, and with very little expenſe of time; the proceſs may be even carried on in the intervals of the time employed upon other operations.

Method of Suerſen.

Suerſen, after having procured ſome pounds of concentrated nitric acid, free from all admixture of ſulphuric by drawing off, ſeparately, the acid which paſſes over in the middle of the operation, dilutes ſeveral ounces of this acid with an equal quantity of diſtilled water. This diluted acid is then poured into ſeveral ſmall glaſs receivers, an ounce into each, which are placed upon a frame made of iron wire. Half an ounce of phoſphorus is now introduced into each of theſe receivers, which are gradually heated by the flame of a ſmall lamp, till a ſufficient action of the phoſphorus upon the nitrous acid is perceived; a conſiderable evolution of nitrous gas immediately takes place, which, however, is not ſo violent

as to impel the phoſphorus to the ſurface of the liquid. If, in any of the receivers, the ſolution of the phoſphorus does not ſeem to go on as it ought, they are heated by applying the lamp to them, and after ſome time, if there is reaſon to apprehend that too great a degree of heat may be produced, the lamp is intirely removed. Should the action in the receivers become very violent, and luminous vapours diſengage themſelves, it may be immediately allayed by the addition of a ſmall quantity of diſtilled water. Thus the phoſphorus muſt be introduced into the acid by ſmall quantities at a time, alternately heating the receivers with the lamp, till the reciprocal action of the acid and the phoſphorus becomes languid, when a freſh quantity of concentrated nitric acid is again added. This alternate introduction of the phoſphorus, the nitric acid, and the diſtilled water, with the application of the lamps, whenever it is required, are continued till the whole quantity of the phoſphorus to be oxygenated is expended. For the complete oxygenation of an ounce of phoſphorus, four ounces of fuming nitrous acid of 1,508 ſp. gr. are generally required, in a temperature of 61° of Fahrenheit, and a ſpace of four hours. In ſix ſmall receivers, and with one lamp, 12 ounces of phoſphorus may be very conveniently oxygenated in one day, reckoning eight hours to the operation. This phoſphoric acid, which is of a dilute quality, and mixed with a ſmall quantity of muriatic and nitric acids, is now ſubjected to diſtillation upon the ſand bath, in which, at firſt, muriatic acid gas, then nitrous acid, and nitrous gas, and afterwards an inſipid water paſs over. If the diſtillation be now continued with an increaſe of heat, an acidulous fluid paſſes over, while pungent vapours are extricated. Theſe vapours have an odour preciſely ſimilar to that of the phoſphoric acid when paſſing into a ſtate of volatilization.

The acid which paſſes over at the beginning of the diſtillation produces no cloud when mixed with lime water; that, on the contrary, which is given out at the end of the operation, precipitates from it a very copious ſediment; a proof of the acid laſt extricated being of a phoſphoric nature; and it appears to Suerſen as well as to profeſsor Scherer, that by a very great increaſe of temperature, a partial decompoſition of the phoſphoric acid is effected. The whole proceſs being now completed, the product is a colourleſs phoſphoric acid, of the conſiſtence of a thick ſirup, the ſpecific gravity of which, at the abovementioned temperature, is 2,0: and from one ounce of phoſphorus 2 ounces and half of concentrated acid are obtained, ſoluble in water with an extrication of heat, poſſeſſing all the properties of pure phoſphoric acid. Such is the proceſs made uſe of by Suerſen.

Diviſion into two acids. The *acid of phoſphorus*, according to the degree of oxygenation it has undergone, may be divided into the phoſphoric and phoſphorus acids. The firſt, or *phoſphoric*, according to the definition of Fourcroy, is a thick liquid compoſed of phoſphorous and oxygen, united by rapid and complete combuſtion, or by any other means; or it is ſolid, vitrifiable by the fire, diſſolving ſilex in it's vitrification, and decompoſable by carbon, which recalls it to a ſtate of phoſphorus again; it decompoſes the nitrous acid, and becomes oxygenated to exceſs by taking a part of it's oxygen. This oxygenated phoſphoric acid is decompoſed by the flame of a candle, producing a very ſtrong detonation; the moment it's oxygen is raiſed to a gaſeous ſtate, it forms phoſphats, with earths, alkalis, and metallic oxyds. The ſecond, or *phoſphorous*, differs from the phoſphoric acid only by having leſs oxygen in union with it; it is very volatile, odorous,

taking and giving oxygen to many bodies, and forming phofphats with earthy, alkaline, and metallic bafes.

1ft. The *phofphoric acid* is a thick liquid, nearly vifcous, forming ftriæ, like certain oils, on the fides of the glafs in which it is fhaken; it is perfectly inodorous, very four, but not cauftic to the tafte, never burning any organic fubftance; it's fpecific gravity is more than twice that of water; it reddens the blue colours of vegetables, is perfectly incombuftible, and enjoys, in a high degree, that property of attracting and of being ftrongly attracted, which the genius of Newton has attributed to acids. Expofed to heat, it becomes thick, concentrated, denfe, and lofes it's water, which evaporates, taking at the fame time a very weak part of the acid along with it. It is thus brought to the ftate of tranfparent jelly, preferving this form in a well corked veffel, but in the air becoming liquid again. If it be ftill expofed to heat until red hot, it melts, fwells, is filled with blebs, and at laft it remains in tranquil fufion. Before the blowpipe, upon a platina fpoon, or in the hole of a piece of charcoal, it is likewife made to take the form of a very tranfparent vitreous globule, refembling the moft beautiful water cryftal. In this ftate of glafs, the phofphoric acid imitates, in brilliancy, the precious ftones, but it is always acid, deliquefcent in the air, and foluble.

Phofphoric acid.

It's properties.

The phofphoric acid, if it be immediately produced by dry combuftion in oxygen gas, attaches itfelf to the fides of the glafs bells in which the heat has fublimed it before inflammation, in the form of very acrid, white, brilliant, cryftallized fcales; but it foon lofes this form, and becomes liquid by contact of the leaft humidity, even of the air. It is neceffary to obferve, that concrete and lamellated phofphoric acid immediately melts into glafs the moment it becomes red hot, without fwelling, or emitting blebs, becaufe it has no water to lofe,

In a liquid and vitreous ftates.

or at leaſt, very little previous to it's taking the vitreous form.

This ſingular vitreous ſtate, of which the phoſphoric acid is ſuſceptible, in no manner changes it's nature, or the proportion of it's principles; it is a proof of it's great fixity, and if it is ſtrange that it contains a ſubſtance ſo volatile as phoſphorus, it muſt be recollected, what a ſolidity the oxygen has acquired by loſing ſuch an enormous quantity of caloric. As to the reſt, the vitreous phoſphoric acid is only obtained very pure, when it is the product of phoſphorus burned by oxygen, and when melted in a crucible of platina; when extracted from it's union with ſome body, it often retains a little earthy, alkaline, or even metallic baſis, with which it was joined. When melted in earthen, glaſs, or metallic veſſels, it diſſolves a part of them, affording on fuſion opake, coloured glaſſes, that are inſipid, inſoluble, do not deliqueſce in the air, are odorous and luminous on being rubbed in the dark. When a very pure phoſphoric glaſs is diſſolved in water, it does not differ in the leaſt from the liquid phoſphoric acid of which it is made. The glaſs once made, is fuſed without motion or vapour; when red hot, it is even ſo fuſible as to ſerve as a flux for many other bodies.

It's action on different bodies.

Light has no action upon phoſphoric acid, which refracts it pretty ſtrongly. It has not, in it's different ſtates, any attraction for oxygen with which it is entirely ſaturated, nor any action on oxygen gas. Expoſed to the air, it only attracts it's humidity; which the dry and concrete takes from the air with great rapidity and force; the thick liquid or gelatinous acid attracts it more ſlowly, but abſorbs nearly half it's weight; the vitreous only becomes humid after a long time, and when it's exterior ſtratum is thick and gelatinous, it defends the interior ſo as to preſerve it's form a long time, and only takes the

liquid ſtate with great difficulty. It undergoes no change from azot, or it's gas, or from hydrogen, or it's gas. Carbon has likewiſe no effect upon it in the cold; but in the heat, when the charcoal is red hot and touches the acid in it's dry or vitreous ſtate, the order of attraction changes, the carbon deprives the phoſphorus of it's oxygen, which is volatilized, whilſt the newly formed carbonic acid is diſengaged.

Such is the theory of the proceſs by which phoſphorus is obtained on diſtilling the dry phoſphoric acid with charcoal. The decompoſition of this acid by carbon, agrees with it's formation in proving it to be compoſed of 0,39 of phoſphorus, and of 0,61 of oxygen. Phoſphorus cannot be combined with this acid directly, either in the cold or by heat; yet this acid ſeems to unite with a greater quantity of phoſphorus, in order to become phoſphorous acid; but this is only by uniting a little oxygen to the phoſphorus at the moment of it's burning, and not by adding immediately more phoſphorus to the phoſphoric acid. Sulphur has no action upon it, nor is the diamond affected by this acid when melted and kept a long time at a red heat. This acid forms no union with carbonic acid, or it's gas; it, however, diſunites it from moſt of it's combinations; thus it ſeparates it from water, producing an effervefcence in acidulous waters, natural or artificial. Water has a great attraction for this acid; when in dry white flakes, it diſſolves in a ſmall quantity of this fluid, producing a noiſe like that from a red hot iron plunged into water, and diſengages a great deal of heat. The vitreous acid is longer in diſſolving, but the liquid concentrated phoſphoric acid unites with it almoſt without heat, and ſlowly. Theſe two bodies may be united in all proportions. The acid loſes more of it's ſavour, denſity, weight, and ſtrength, in proportion to the quantity of water added. The water is only ſepa-

rated from this combination by means of heat; it is much more volatile than the acid, which is concentrated in proportion to it's disengagement, in the form of vapour. The acid, during the evaporation, passes successively through the states of thick liquid, viscous fluid somewhat gelatinous, and glass.

Earthy and alkaline phosphats.

The phosphoric acid forms with alkalis and earths salts, the generic characters of which are, to afford no phosphorus when heated with carbon, but be fusible into opake or transparent glasses; they are phosphorescent at a high temperature, are soluble in the nitric acid without effervescence, are precipitated from this solution by lime water, and are called *phosphats*. The phosphat of potash is not crystallizable, but deliquesces, and affords, with limewater, a precipitate soluble in acids, without effervescence. Phosphat of soda is very crystallizable, effloresces, is very fusible before the blowpipe, affording an opake glass on cooling, giving the same precipitate as the preceding by limewater, easily taking an excess of soda; it is purgative. Phosphat of ammonia is crystallizable, decomposed by heat, which melts it into a transparent acid glass; it affords phosphorus with carbon. Phosphat of soda and ammonia; this exists in animal fluids, is very crystallizable, affording by lime an insoluble precipitate and an ammoniacal vapour at the same time. Phosphat of magnesia is crystallizable, has a sweetish taste, very little soluble, uniting, although very neutral and saturated, to ammonia, into a sort of triple salt; it exists in human urine. P. ammoniaco-magnesian is very little soluble, without savour, often deposited in human vesical calculi, in the form of white spathic strata, affording an ammoniacal vapour, and magnesia, by the contact of caustic alkalis. P. of glucen is sweetish to the taste, and affords, by means of lime, a precipitate soluble in carbonat of ammonia. P. of alumin is of a thick and gelatinous

confiſtence, and yields a precipitate to all the baſes, which is rediſſolved by cauſtic alkalis. P. of ſilex is in a vitreous ſtate reſembling a gum, is inſipid and inſoluble, only becoming ſoluble in acid after having been melted in four times it's weight of alkali. P. of lime is inſoluble and inſipid, forming a kind of porcelain when expoſed to a great heat, exiſting, in it's natural ſtate, in the form of ſtones, and ſometimes cryſtallized; it is inſoluble in phoſphoric acid, and paſſes to the ſtate of acidule by the other acids. Acidulous P. of lime is ſour to the taſte, is in the form of ſcales reſembling mother of pearl, is inſoluble, and not to be decompoſed by acids. P. of ſtrontian is inſoluble, it reddens the flame of the blowpipe, and is decompoſed by lime and barytes. The component parts of the phoſphats are as follow:

Phoſphat of ſtrontian —	Phoſphoric acid -	41.2
	Strontian - - -	58.76
of lime —	p. a. - - -	41.
	Lime - - -	59.
acid of lime —	p. a. - - -	54.
	Lime - - -	46.
of ſoda and ammon.	p. a. - - -	32.
	Soda - - -	24.
	Ammonia - -	19.
	Water - - -	25.

No metal can unite with the phoſphoric acid in it's metallic ſtate; the acid undergoes no change with metals at any temperature. Several of them, however, acquire, by the addition of this acid, the property of decompoſing water, and of diſengaging the hydrogen from it in the form of gas, abſorbing it's oxygen. On heating the moſt combuſtible metals with the vitreous phoſphoric acid, although none of them has really more attraction for the oxygen than phoſphorus had, there is, however, by means of a double attraction, a formation of oxyd

Metals and their phoſphats.

and metallic phoſphorus. To obtain this kind of compoſition, three parts of metal, with one of concrete phoſphoric acid, are to be ſtrongly heated in a crucible; this laſt diſappears entirely, and inſtead, the metal is found in part oxydated, and in part combined with phoſphorus; for the quantity of metal being greater than what is neceſſary to abſorb all the oxygen contained in the acid; a part of this metal acts on the oxygen of the acid, whilſt the other acts on the phoſphorus; and hence an oxyd and a metallic phoſphorus ariſe. The phoſphoric acid combines eaſily with moſt metallic oxyds, with which it forms ſalts fuſible in the fire, very little ſoluble in water, but ſoluble in the phoſphoric acid, ſome of which are cryſtallizable on cooling, after fuſion. The greater part heated with charcoal afford phoſphorus or metallic phoſphures.

Silver. The phoſphoric acid precipitates ſilver from it's nitric ſolution, and unites with the oxyd, forming the phoſphat of ſilver. This is thick, heavy, and of a white colour, melts by a great heat into a greeniſh or olive-coloured enamel, according as it is more or leſs heated. This phoſphat is inſoluble in water, but diſſolves in an exceſs of phoſphoric acid. Treated with charcoal in a retort, it affords a little phoſphorus, and is in great part reduced to a phoſphure of ſilver, containing from 0,15 to 0,20 of phoſphorus.

Copper. This acid is not decompoſed by copper, but on remaining ſome time upon this metal, it aſſiſts it's oxydation either by the water or air, and forms phoſphat of copper, which is very little ſoluble. It is immediately obtained by pouring ſolutions of alkaline phoſphats into moſt of the mineral ſalts of copper; a double decompoſition takes place; the phoſphoric acid unites with the oxyd of copper, and forms a precipitate of greeniſh coppery phoſphat, nearly inſoluble. It's properties have not been examin-

ed; heated however with charcoal in a crucible, it affords a brilllant grey phoſphure of copper.

If acid combines very ſlowly with iron, it however at laſt oxydates it, and forms a phoſphat of iron, which is an inſoluble ſalt. It may be prepared by pouring ſolutions of alkaline phoſphats into thoſe of ſulphat, nitrat, or muriat of iron, when a double exchange takes place. The precipitate or phoſphat is white. It is eaſily reduced by red hot charcoal into a metallic phoſphure. As urine is found to act upon iron, this metal ought not to be expoſed to places where this fluid is conſtantly met with, as the phoſphoric acid it contains corrodes it. Iron.

It only attacks lead very ſlowly, and converts it by degrees into an inſoluble white phoſphat. Alkaline phoſphats likewiſe on being mixed with nitrat of lead, or with the muriat by heat, form it. This phoſphat of lead, which appears to become ſoluble by exceſs of phoſphoric acid, and even by other acids, is fuſible in the fire, and on cooling forms regular polyedrons. It is decompoſed by red hot charcoal, which converts it into phoſphorus and lead, whilſt itſelf becomes carbonic acid. The ſulphuric, nitric, and muriatic acids decompoſe it in the moiſt way, by which the acid is ſeparated; alkaline carbonats alſo decompoſe it. Lead.

It has ſcarcely any action upon tin in a liquid form, and in the cold. Soluble phoſphats poured into muriat of tin afford a precipitate of phoſphat of tin. Vitreous phoſphoric acid, treated with half it's weight of tin, is decompoſed; on one ſide, vitrified phoſphat of tin is formed; on the other, phoſphure of tin. Pelletier firſt made this known. Tin.

This acid diluted forms with zinc a phoſphat in the form of a white powder; hydrogen gas is diſengaged from the water. It is alſo obtained as a white precipitate, when the phoſphats of potaſh, ſoda, or ammonia are Zinc.

added to a folutlon of the fulphat, nitrat, or muriat of zinc. This metal ftrongly heated with vitreous phofphoric acid, reduces a portion of it to phofphorus, and forms with it a phofphure of zinc.

Quickfilver. This acid, although it has no effect on quickfilver, unites to it's oxyd. This union however is not well accomplifhed but by precipitating nitrat of mercury by a folution of the alkaline phofphat, when an infoluble white precipitate of mercurial phofphat is formed. Moft animal fluids afford this falt mixed with mild muriat of mercury, by means of nitrat of mercury. This phofphat is luminous and phofphorefcent when rubbed in the dark; expofed to heat, efpecially with a little charcoal, phofhporus is produced.

Manganefe. It does not act on manganefe, and only diffolves it's oxyds with difficulty; the phofphat of manganefe is obtained by pouring a folution of alkaline phofphat into that of nitrat or muriat of manganefe.

Nickel. It has only a weak attraction for the oxyd of nickel; the folution is fcarcely greenifh, and affords no cryftals.

Cobalt. It diffolves the oxyd of cobalt, and forms a reddifh liquor which becomes turbid, and is depofited when the acid is faturated.

Uran. United to the oxyd of uran, it forms flakes of a yellowifh white colour, very little foluble in water.

Titan It precipitates the oxyd of titan from acids, in the form of a white powder.

Such is the account that Fourcroy gives of the action of this acid upon faline bodies and metallic fubftances, by which it appears how weakly it affects metals, on account of the ftrong adherence of their principles. By expofing them however to a great heat, towards the end of the procefs, phofphorated hydrogenous gas is extricated. Metallic phofphats are heavy and decompofable by feveral acids. If the vitreous acid be ftrongly heated with

metals, the laſt by depriving it of a portion of it's oxygen form two combinations at the ſame time, viz. phoſphats and metallic phoſphures.

Properties of earthy and alkaline phoſphats.

Some of the earthy and alkaline phoſphats exiſt in abundance in foſſils, a greater number in animal fluids, ſeveral in vegetable matters, but the greateſt quantity is the creation of art alone. Some of them were known towards the middle of the 18th century, for before this time they had been confounded with muriats. They are formed by the phoſphoric acid, and are kept in cloſe bottles. They are in general cryſtallizable, their ſavour often ſaline, mild and freſh, very much like muriats, and ſeveral chemiſts regard them as the heavieſt of ſalts. Light has no action upon them; all are fixed in the fire, eaſily fuſed to a glaſs, ſometimes tranſparent, ſometimes opake; moſt emit on perfect fuſion, or even before any fuſion, a light, a ſplendour or phoſphoric flame, particularly before the blow pipe upon charcoal, although in general this character is weak; by this means, the greater number only loſe their water during fuſion and preſerve their ſaline nature. Oxygen or azot has no effect upon them, hence whatever ariſes from the contact of the air is from the water. Some undergo no change in it, others effloreſce and loſe their cryſtalline form, whilſt others attract a ſlight humidity. Although the phoſphoric acid is decompoſed by hydrogen and carbon heated, or red hot, and gives up it's oxygen, converting them into water and carbonic acid, yet theſe two ſubſtances have no effect upon phoſphats at any temperature; the only exception is perhaps the phoſphat of ammonia, and this is only apparent, for it has loſt it's ammonia when this takes place. Phoſphorus, ſulphur, and the metals have no effect upon phoſphats, and if metals are in ſome degree changed by theſe ſalts, it is to be attributed to their water of cryſtallization, or ſolution. Theſe phoſphats are

either very ſoluble or almoſt entirely inſoluble, moſt of the firſt are ſo, more from the heat, and cryſtallize on cooling; the ſecond are always in powder, although nature ſometimes preſents them cryſtallized; hence the ſecret of their ſolution. All metallic oxyds combine with phoſphats by heat, and produce coloured vitrified compounds of different colours, uſed in the arts; theſe are produced either before the blowpipe or in a crucible. Some acids have a remarkable effect upon them; the ſulphuric decompoſes the greateſt number, and only a part of thoſe capable of being acidules; the phoſphoric unites with ſome, and converts them into acidulous phoſphats; the nitric decompoſes nearly all, and the ſolution, always acid, contains nitrats and phoſphoric acid, or nitrats and acidulous phoſphat with reſpect to thoſe it only decompoſes in part; the ſame with the muriatic; the ſulphurous, nitrous, phoſphorous, fluoric, boracic, and carbonic have no effect. It is by their decompoſition, by the ſulphuric, nitric, or muriatic acids, that their exact analyſis and proportion of their parts is known; for as the phoſphoric acid is eaſily known when ſeparated, the kind of ſalt is eaſily diſcovered. Earths capable of vitrification eaſily unite with thoſe ſalts by fuſion into various kinds of glaſs, or enamels more or leſs opake, by forming triple combinations; other baſes are differently affected by phoſphats, according to the nature and peculiar attractions they have to the phoſphoric acid. Such is the account of this acid and it's effects on bodies as given by Fourcroy.

The phoſphoric acid uſed previous to the diſtinction between phoſphoric and phoſphorous acids.

On examining authors who have publiſhed their experiments on the different combinations of the phoſphoric acid with other ſubſtances, it is often difficult to know whether they are ſpeaking of phoſphats or phoſphites, as they have rarely explained what kind of acid they made uſe of, and the manner how obtained it; from this ariſes

the different refults chemifts have met with in their experiments. On defcribing therefore the action of this acid on other bodies, and in giving an account of it's hiftory, that *acid of phofphorus* is fuppofed to have been ufed that was employed before any diftinction was made between the phofphoric and phofphorous acids, or at leaft before it was attended to by the generality of chemifts.

We are informed, that when this acid is melted with gold leaf a purple fcoria is produced, it changes red precipitate to yellow and white, and by long digeftion to black; it completely diffolves white arfenic, but not the regulus. It diffolves zinc perfectly; the folution exhales a fetid fmell, but yields no cryftals on evaporation; a gummy mafs remains, which, on fufion, becomes a tranfparent glafs. It diffolves the regulus of antimony, and more readily it's precipitate by fixed alkali, and the combinations with this metallic fubftance are alfo eafily vitrefcible by heat. It attacks bifmuth and it's calx. With regulus of manganefe it forms a red folution, and the fame with it's calx, which however becomes white on expofure to the air. When this acid is treated with metallic fubftances in the *dry way*, it's action is more powerful, and with tin, lead, and efpecially iron and zinc, it forms phofphorus. With refpect to it's effects on metallic folutions, it precipitates gold from it's folution in it's metallic ftate, and filver likewife. A folution of mercury yields a copious white precipitate, which, according to Margraaf, rediffolves on ftanding. With iron, the phofphoric acid, after having eafily diffolved it, forms, when in a large proportion, a cryftallizable falt; and with a lefs proportion, a compound infoluble in water, but foluble in acids; the folution is accompanied with effervefcence and difengagement of hydrogen gas. When the folution of iron in this acid is diluted confiderably with water, even although the acid abounds, a precipitate falls

either immediately, or after fome expofure to the air. This precipitate is of a blueifh colour, is infoluble in water, but is changed by it to a green. This folution of iron when precipitated by a fixed alkali gives a white powder, which afterward becomes green; by the pruffian alkali, a blue powder; and by infufion of galls a black fediment. Thefe precipitates are not mere calces of iron, but contain fome portion of the acid; particularly the powder that is depofited merely by dilution with water, or by expofure to the air, is a perfect compound of phofphoric acid and iron. According to Weftrumb it has a ftronger affinity to zinc than to any other metallic fubftance.

The phofphoric acid has when concentrated a ftrong action on oils; it at firft difcolours them, and at length blackens or carbonizes them; producing heat and a ftrong fmell, like that of a mixture of ether and oil of turpentine; but, according to Ker, it does not form a true foap, which property, according to Cornette, is peculiar to the vitriolic acid. It has moft effect on *effential oils*, lefs on *drying oils*, and leaft of all on fat oils. In fpirit of wine it is faid by fome to be foluble, by others not. It's action on animal and vegetable fubftances is more or lefs lively, according to it's degree of concentration, and deprived of all humidity that it has received by deliquefcence, it is ftill capable of deftroying in time their texture and colour.

Prieftley attempted to convert the acid into a ftate of gas, but he found that at the common temperature of the atmofphere it was recondenfed, without having undergone any change. In a concrete cryftalline form, de Trudaine found, that it only melted in the focus of a burning-glafs, when placed on a piece of charcoal, which Macquer attributes to the facility with which light traverfes tranfparent bodies. Berniard has announced, from

the obſervation of Cornus, that phoſphoric glaſs has the property of being the moſt electric of all known glaſſes.

Miſtaken for other acids.—Boyle appears to have looked upon the phoſphoric acid as being the muriatic, and Henkel and Stahl conſidered it as a modification of the muriatic acid brought about by phlogiſton. This opinion was founded on the circumſtance, that urine, from which phoſphorus was obtained, contained both theſe ſubſtances in great abundance; and when common ſalt was placed upon burning coals, a vivid blueiſh flame aroſe, ſimilar to that from phoſphorus: this hypotheſis has been abandoned ſince the experiments of Margraaf, who endeavoured by all poſſible means to form the combination, but without ſucceſs; he, however, out of reſpect for Stahl's opinion, ſeems not entirely to have denied, that it might be of the nature of the muriatic acid, but not in it's pure ſtate. He thought it perhaps might be the ſame acid, but united in a peculiar way to a very tender glacial earth. Other writers, as Hoffmann, Wenzel, Vogel, and Pœrner were of opinion, that the phoſphoric acid is compoſed of the vitriolic and muriatic acids; but as theſe two acids could not be produced by the decompoſition of the phoſphoric acid, nor the phoſphoric acid produced by the compoſition of them, it began to be conſidered as a peculiar acid. Boſc d'Antic, as well as Sage, thought it contained the matter of the fluor, aerial, and urinous acids; even Sage carried it ſtill farther, and raiſed this acid to the honour of the original and elementary acid. He thought he could trace it in fixed alkalis and in metallic calces, and conſidered it as the ſole principle of vitrification. This chemiſt, however, wanted facts to ſupport his aſſertions. Macquer attributes to it the nature of ſedative ſalt and white arſenic: thus, he ſays, that ſedative ſalt, in many caſes, takes place of an acid, without openly ſhowing acid properties; it unites with alkalis, ſatu-

Phoſphorus taken for other acids.

rates them, and changes them into neutral ſalts. In the fire, it is fixed, and melts, like the phoſphoric acid, into a glacial matter; and laſtly, it precipitates, like it, neutral ſalts from their mixtures. With reſpect to arſenic, it is not ſo fixed as the phoſphoric acid, and only decompoſes ſalt petre; but it is as much diſpoſed to vitrify as this acid, and as to it's ſmell, it perfectly reſembles that of phoſphorus. With reſpect, however, to it's power of promoting vitrification, Ker obſerves, it is by no means peculiar to theſe acids and alkalis. The marine acid exerts it very conſpicuouſly upon clay, in thoſe potteries where the glazing is given by marine ſalt volatilized by heat, in which operation the effect is greater than the alkali alone of the ſalt could produce; whilſt from Pott's experiments, the greater fuſibility of gypſum, when mixed with other earths, than pure calcareous earth, ſhows the vitrifiable powers of the vitriolic acid; and this power is ſtill more conſpicuous in the acid of fluor; hence the idea of Macquer is likewiſe falſe.

Compoſition of the acids.

From the proceſſes of obtaining the phoſphoric acid from phoſphorus, it appears, that it conſiſts of phoſphorus united with the pure air of the atmoſphere, which it abſorbs, and by which it's weight is conſiderably augmented. If the operation be performed ſlowly, not only the pure part of the atmoſpheric air is abſorbed, but alſo a ſufficient quantity of moiſture is attracted to produce a liquid acid. If, however, the operation be performed in a veſſel filled with pure air, confined by mercury, and particularly placed in a hotter temperature, white fumes will ariſe, and light flocks will float in the air, and attach themſelves to the ſide of the veſſel. This is a concrete acid, which ſoon attracts moiſture when expoſed to the atmoſphere and deliqueſces.

Hence the phoſphoric acid is compoſed like all the

other acids, *i. e.* of a radical or peculiar acidifiable bafis, and vital air, which is the common acidifying principle. Scheele, having enclofed a piece of phofphorus in a phial the capacity of which equalled feven ounces of water, filled with vital air, and having applied fome heat to it by means of a candle, found that the external air preffed fo ftrongly on the ftopper, that he was obliged to put it under water. Another time, the fame chemift obferved, that nine grains of phofphorus placed in a glafs veffel, fealed hermetically, the capacity of which was equal to 30 ounces of water, had diminifhed the common air during the combuftion about 9 oz. by meafure. According to Kirwan, it is a circumftance worthy of great attention, that the air is much more diminifhed by phofphorus than by any other combuftible fubftance; but Morveau thinks that this difference cannot be attributed to the greater degree of heat produced, fince this heat is itfelf the effect of a greater diminution or decompofition of vital air; but he thinks with Scheele, that the reafon of the abforption being here more confiderable, arifes from the combuftion not being difturbed, as in other fimilar experiments, by the vapours dilated by the heat, and which furround the flame.

Great diminution of the air, and great heat from the produce of the acid.

According to the experiments of Lavoifier, confirmed by thofe of de la Place, 45 grains of phofphorus abforbed, on burning 65, 62 grains of vital air, and in the formation of the phofphoric acid, one part of the phofphorus combines with 1 $\frac{4}{9}$ of vital air, Thefe learned academicians obferved, that the heat, difengaged by the vital air, when it was abforbed by phofphorus, was nearly 2 $\frac{1}{3}$ greater than when it was changed into fixed air.

It remains now to know what is the bafis which phofphorus furnifhes in the formation of the acid, to the acidifying principle. According to the principles of

The radical and acidifying principle.

Stahl, when reconciled to the most modern discoveries, it is a peculiar substance of it's own kind, which, by it's union with phlogiston, constitutes phosphorus. Lavoisier, on the contrary, has laid it down to be the phosphorus itself, which, uniting with the oxygen of the air forms the acid, which is now the generally received opinion.

Phosphoric acid formed in all the kingdoms.

The phosphoric acid was formerly thought peculiar to animal substances; but Margraaf found it also in the vegetable kingdom, and was able to obtain phosphorus by distilling wheat, mustard seed, and other vegetable matters; and Gahn discovered it in the ore of lead; hence it's existence has been found in all the three kingdoms. With respect to the *animal*, there is, perhaps, no part of animal bodies free from it. It was observed particularly to exist in urine, partly united with soda, partly with volatile alkali, and partly with calcareous earth. Scheele and Berthollet found, that it also existed in this animal fluid, in a disengaged state, and that it betrays it's presence in recent urine by it's effect on the colour of litmus. Homberg found it in blood. It is found in large quantity in bone, which Gahn discovered in 1769. Scheele found it in stags' horns; Maret, in flesh; and Proust found the fresh decoction of flesh to redden turnsole from this acid. Crell found it in ox suet and human fat; Hankewitz, in human excrements; Leiden, Henschen and Andrea, in old cheese; Berthollet, in sweat; Hohenholz, in crabs eyes; Marquis de Bouillon, in fish bones. Crell has extracted it from beef suet and human fat; Macquer and Struve, from the gastric juice; Henchel saw it in the sweat; Berniard got it from egg shells; and Hatchett, from other shells of different kinds. In the *vegetable* kingdom, Albinus, Lauth, Hoffmann, and Pott, had long ago mentioned it's existence; and Margraaf, as before observed, in mustard

ſeed; Meyer found it in the green reſinous part of leaves, to which he attributes the colour; and Berthollet, in thoſe plants which yield volatile alkali, where he thinks it chiefly reſides. Haſſenfratz obtained it from potatoes, agaric, ſoot, and woods of different kinds, and from marſhy plants, charcoal and foſſil coal. Weſtrumb likewiſe obtained it from charcoal in the following manner. He phlogiſticated a fixed alkali by melting it with charcoal, to which he added ſome ſal ammoniac. The lixivium of this alkali he ſaturated with vitriolic acid, and added to it a ſolution of iron in marine acid, upon which a precipitate was formed, conſiſting of phoſphoric acid and iron. In the *mineral* kingdom, after Gahn had found it in lead, Prouſt announced that it would be in other metallic bodies, and it was found in the marſhy ores of iron by Meyer, Stettin and Bergman, forming with the iron the compound called ſiderite, to which has been attributed the cold-ſhort quality of iron; by Klaproth, in a ſpecies of beril called by Werner apatit, in which the acid is united with calcareous earth. Haſſenfratz attributes the phoſphoric acid found in marſhy ores of iron to the aquatic plants and animals, in which his experiments have proved the exiſtence of that acid; and he ſuppoſes theſe marſhy ores to be of modern date, and formed by depoſition of waters, and conſequently replete with vegetable and animal matter; but he never found this acid in thoſe ores which lie in the more antient ſtrata, as the magnetic, black, pyritous, hepatic, and ſpathoſe; yet he diſcovered traces of it in caſt iron, even in that which had been made from theſe latter ores; and this he attributes to the charcoal employed in the fuſion. This acid is likewiſe an ingredient in the formation of mountains. Thus Bowles has deſcribed a large native maſs of a phoſphoric ſtone, of which many hills are compoſed, near Lagroſo, a village in Eſtremadura, a

province of Spain. He informs us, that this ſtone is whitiſh, and without taſte, and that it gives a blue flame without ſmell, when thrown on hot coals. Prouſt further deſcribes this ſtone as denſe, not hard enough to ſtrike fire with ſteel, and ſays it appears in ſtrata, which always lie horizontally upon quartz. When this ſtone is ſcattered upon burning coals it does not decrepitate, but burns with a beautiful green light, which laſts a conſiderable time; and in this reſpect, it is not unlike the fluor ſpar, the light of which, however, is more blue and leſs durable. With the vitriolic acid it forms a ſelenite, while the remaining liquor is the phoſphoric acid, ſimilar to that obtained by diſſolving bones in the vitriolic acid. Hence the ſtone is a calcareous phoſphat.

It's origin. As the phoſphoric acid is found in each of the three kingdoms, the great queſtion is to know from which it derives it's origin. Margraaf having diſcovered it in vegetables, thought it was formed there, and thence conveyed into animals. Ker is of opinion, that as it exiſts more copiouſly in animals than in vegetables, and as acidification conſiſts in the union of air with ſome inflammable matter, which proceſs is manifeſtly carried on in the lungs of animals, where, by reſpiration, pure air is continually abſorbed, and combined with the moſt diſengaged inflammable matter it can find in the blood; it is not improbable, that it may be formed alſo in the bodies of animals, and that as large quantities are continually carried off from them in their excretions, he conjectures, it's formation and ſubſequent excretion are a mode employed by nature to carry off the phlogiſtic matter, as ſoon as it comes to a proper degree of diſengagement, which is continually evolved in the animal proceſs, and which, if not combined, would cauſe immediate death. It would appear, that the phoſphoric acid is formed both by vegetables and animals, which are only degrees of

the ſame organization, and that the more animalized a body is, the larger is the quantity of this acid it contains; it's quantity in animals is conſiderable, where it is not only combined with ſoda, lime and ammonia, but is alſo in a diſengaged ſtate, as it is found in fleſh and in urine.

Hiſtory of the acid of phoſphorus. This acid was unknown to the ancients. When it was firſt diſcovered, and a long time afterwards, having been generally procured from urine, it was called by ſome chemiſts, the *acid of urine.* But ſince it has been found to exiſt in other ſubſtances, and more particularly in bones; and another acid, which poſſeſſes different properties, was equally found in urine; the name of the acid of urine has given way to that of the phoſphoric acid, particularly ſince it was obtained from phoſphorus by combuſtion. The phoſphoric acid appears to have been diſcovered the latter end of the ſeventeenth century. Boyle, on examining the clear liquor which the flowers of phoſphorus afforded, found by the taſte that it was acid; it changed the ſirup of violets to a fine carnation colour, and diſſolved the filings of copper; and he compared it to the ſpirit of ſea ſalt. Frobenius, on applying heat to ſome phoſphorus, obtained from it a large quantity of very white flowers, and having admitted air to them, they melted into a clammy liquor, reſembling gum water; by heat, they became hard and tranſparent. He gave to theſe the name of vitrum molle; being expoſed to a ſtrong heat they became brittle like glaſs. He informs us he procured an acid from them. Hankevitz having deflagrated ſome phoſphorus, obtained a quantity of flowers from it, and found they had gained 2 drachms in weight; theſe being placed in a cool ſituation became diſſolved into a liquid that had gained ſtill more in weight. He informs us likewiſe, that it contained an acid ſalt,

Boyle.

Frobenius.

Hankevitz.

more fixed in the fire than any ſalt then known, and had other properties peculiar to itſelf. Slare. Slare found, that after the deflagration of phoſphorus no aſhes remained, but there was inſtead a little moiſture that taſted ſubacid, reſembling a weak oleum ſulphuris per campanam. It ſet his teeth on edge, and diſſolved iron. He tells us, that a piece of phoſphorus when reſolved into this liquor, weighed at leaſt thrice it's original weight. It appears, therefore, that ſo early as between the years 1679 and 1698, when Boyle and Slare publiſhed their papers, an acid had been diſcovered to be produced by the ſpontaneous and artificial combuſtion of phoſphorus; that it had even received an increaſe of weight during the change, and that it was to be obtained in a concrete form; but it was unknown to be a peculiar acid, ſince known by the name of the phoſphoric, and conſequently none of it's properties had been examined. Even at the time of Hellot, in 1737, it was ſuppoſed, that the deliqueſcence of phoſphorus was only a real ſolution brought about by the tenuity of the aqueous particles, in a ſtate of vapour, and becauſe it's inflammable principle was diſſipated. The chemiſt who firſt gave any ſatisfactory account of this acid, and who deſcribed it's properties, was Margraaf, about the year 1743 (a detail of whoſe experiments will be given hereafter).

It has been already ſaid, that there are three methods of obtaining the phoſphoric acid, viz. by deflagration, ſlow combuſtion, or by affinity in the humid way.

First method of obtaining the acid. *The deflagration of phoſphorus* is a lively and rapid combuſtion; and if this ſubſtance be placed in a veſſel ſo that it may be expoſed, either naturally or artificially, to a degree of heat of about 24 degrees of Reaumur, it enflames with a kind of exploſion; the bottom of the veſſel is found covered over with a flaky white matter, the weight of which is more than double that of the phoſphorus itſelf,

which very readily and powerfully attracts humidity from the air, and is at laſt converted into an acid fluid, of the conſiſtence of a thin oil; and this is the phoſphoric acid. Without waiting, however, for the deliqueſcence, a certain quantity of water being poured upon this reſiduum ſoon diſſolves it, except a portion of yellowiſh orange matter, which is phoſphorus not decompoſed, and which remains on the filter. This operation by deflagration has been deſcribed by Margraaf, who obſerved, as well as Hankevitz and Slare, that the product had increaſed in weight; and it was upon the ley of this reſiduum, concentrated by diſtillation of the phlegm, that he made his firſt attempt to inveſtigate it's combinations. To obtain the acid, he deflagrated the phoſphorus in a glaſs mortar, which he placed upon a glaſs or porcelane plate, gently heating the laſt at the bottom: he likewiſe placed it under a cucurbit covered with an alembic, making uſe of a receiver. By this means, from one ounce of phoſphorus he obtained, by deflagration, one ounce and ⅛ of a drachm of the acid; and the acid thus prepared, according to Margraaf's proceſs, has been called the *phoſphoric acid by deflagration*. (Acidum phoſphori per deflagrationem).

Lavoiſier tells us, that the method he uſed to procure the phoſphoric acid for his experiments was, to burn the phoſphorus under a glaſs bell inverted in mercury, by means of a burning lens; a great abundance of white flocks attach themſelves to the ſides of the veſſel, which are the concrete acid, and are almoſt immediately diſſolved into a fluid ſtate on coming into contact with the air; the product is a very concentrated and heavy acid, without odour, and has the oily appearance of the concentrated vitriolic acid. If the acid is wanted of leſs ſtrength, this chemiſt has given a more eaſy and expeditious method: the phoſphorus is deflagrated under Lavoiſier.

large glaſs bells, into which a little diſtilled water has been poured: when the vapours ariſing from the firſt combuſtion are diſſipated, a freſh quantity of phoſphorus is introduced under the veſſel, which is to be deflagrated like the firſt, and the proceſs is thus to be continued for ſeveral days, until a ſufficient quantity of phoſphoric acid is obtained; but although this proceſs has the advantage of affording the acid in a ſhort time, yet it holds in ſolution a pretty conſiderable quantity of phoſphorus undecompoſed, which alters it's properties.

Wolfe and Pelletier.

Wolfe and Pelletier invented a proceſs for obtaining this acid by combuſtion, by melting this ſubſtance under water, and by paſſing a current of pure air through it.

Second method.

2d. *Phoſphoric acid* is obtained by a more complete converſion of the phoſphorus, on ſubmitting the latter ſubſtance to a *ſlow combuſtion*; for if phoſphorus be expoſed during ſome weeks to the ordinary temperature of the atmoſphere, even in the winter, it undergoes a ſlow combuſtion, and is gradually changed into a liquid acid. For this purpoſe, it is uſual to put ſmall pieces of phoſphorus on the inclined ſide of a glaſs funnel, through which the liquor, which is formed, drops into the bottle placed to receive it.

Boyle.

Boyle, having placed about 3 grains of phoſphorus in a glaſs funnel, which he ſet in the window, it continued to ſhine for fifteen days, and there was left behind a liquor, which, on being weighed, he found to have increaſed to three times it's weight; but he was ignorant, as before obſerved, either of it's being a peculiar acid, or of the cauſe of the increaſed weight.

Slare.

Slare having expoſed half a grain of this ſubſtance in the open air, it continued to flame ſeven or eight days, and when it was extinguiſhed no aſhes or recrements remained behind except an acid moiſture, of which he knew nothing.

Sage recommends to cover the orifice of the funnel into which the phoſphorus is put with a cucurbit; and as the end of the funnel enters a bottle into which the acid falls, a ſmall glaſs tube ſhould be placed in the middle of the funnel to give vent to the air of the bottle, which is diſplaced by the acid; for without theſe precautions, the phoſphorus would inflame with exploſion in the apparatus, when the thermometer is at 15° above the freezing point. The inflammation may take place even at a very inferior degree, when there is a certain quantity of phoſphorus, or if the pieces of phoſphorus touch, or are too near each other, which, we are informed, happened once even in a cellar belonging to the academy of Dijon. Sage.

By ſlow combuſtion, Morveau, Maret, and Durande, obtained from one ounce of phoſphorus three of the acid, and when thus prepared, it has been called *phoſphoric acid by deliqueſcence,* (acidum phoſphori per deliquium.) It is without odour or colour, of the appearance of concentrated vitriolic acid; but it ſtill retains ſome undecompoſed phoſphorus, which is obſervable on being expoſed to the fire, by it's very acid, white vapours, and ſmall luminous exploſions; and although this portion of phoſphorus is very ſmall, yet it may lead to error on making any délicate experiments; but it is eaſy to deprive the acid of it by diſtilling it upon ſpirit of wine, which does not volatilize it, and which takes hold of the phoſphorus.

According to Morveau, the name of *acid by deliqueſcence* is very improper; for it is not the water that decompoſes the phoſphorus, and converts it to the ſtate of acid; it is only attracted by the acid perfectly formed, or in proportion as it is formed, by a real combuſtion, which only differs from the preceding by being much more ſlow, as is evident from the odour which the phoſphorus does not ceaſe to exhale, and the light it diſperſes during

the whole procefs, and which, although weak, is however fenfible in the dark. The air is therefore the only agent of the decompofition. The acid procured by means of Sage's method by water may be deprived of that fluid, and brought to a thick, or even a glacial confiftence, by evaporation and diftillation.

3d method. 3. With refpect to the third method, or that by affinity, it is now well known, that phofphorus as well as fulphur is fufceptible of paffing into an acid ftate by means of *affinities in the humid way*, without any inflammation either vivid or flow; but, as Morveau has expreffed it, by a fpecies of cold combuftion; thus it is eafily obtained by means of the nitrous acid.

Scheele. Scheele was the firft who obtained the phofphoric acid by the nitrous acid; it was afterwards procured by Chaptal; but Lavoifier has given a more convenient form of procefs, of which the following is an account: He took a tubulated retort containing fix or feven pints, into which he poured two pounds of nitrous acid, of a fpecific gravity to water as 129895 to 100000, and placed it on a fand bath; to this he adapted a receiver; he then applied by degrees a heat until the liquor had acquired about 45°, and put into the retort a piece of phofphorus of 10 or 12 grains in weight, which immediately fell to the bottom of the liquor, melted like wax, and produced a very lively effervefcence; when the firft piece was diffolved he put a fecond, then a third in, and repeated this by flow fucceffions, until he had combined all the phofphorus he wifhed to diffolve with the acid. The quantity was 2 oz. 6 or 7 drachms. The folution in the beginning was made with great eafe, fo that he was obliged to manage the fire left the effervefcence fhould be too great; but towards the end the action of the acid upon the phofphorus became by degrees flower, and it became neceffary, in order to fupport the effervefcence and the folution, to

Lavoifier.

raiſe the heat to ſuch a degree as to exceed that of boiling water. Whilſt only a drachm or one drachm and a half of phoſphorus had been diſſolved, the liquor underwent no change, except receiving a yellow tinge like aqua regia; afterward it became green; at the ſame time very thick, red and turbid vapours aroſe, which were only nitrous air and very fuming nitrous acid. Theſe vapours, which formed a thick cloud, appeared to fall and run from the orifice of the retort, like a liquid, and continued to paſs all the time of the ſolution of the phoſphorus. The products, however, which paſſed during the diſtillation being collected, and which continued 17 or 18 hours, were as follows: at firſt 2 drachms 24 grains of a very weak nitrous acid, nearly white, came over, and the vapours which aroſe from the liquor in the retort during the time this acid paſſed over were ſcarcely coloured; but as the vapours became more intenſe, the acid which aroſe was more yellow, and began to fume; the ſecond portion which was ſet apart weighed 3 oz. 50 grains; this ſecond portion was followed by a nitrous acid of a deep green yellowiſh colour, and more fuming than the preceding; it weighed 6 oz. 2 drachms: the nitrous acid obtained afterwards was rather leſs green, and not ſo fuming, it weighed 5 oz. 5 ½ drachms; and toward the end of the paſſage of this acid, the intenſity of the red vapours conſiderably diminiſhed, and nothing was now obtained but white nitrous acid ſcarcely fuming; this laſt portion weighed 4 oz. 2 drachms, 6 grains. The liquor in the retort was now entirely ſaturated with phoſphorus, and the portions added would not diſſolve, although the heat was greatly increaſed and long continued. Having taken off the veſſels, there remained in the retort 13 oz. 4 drachms of a ſomewhat yellowiſh liquor, of an oily conſiſtence, almoſt like concentrated vitriolic acid or oil of vitriol, which had ſtill a little of the odour of nitrous

acid. To fend off the laft remains of volatile acid it might contain, it was put into a glafs retort clothed with earth, and expofed to the graduated heat of a reverberatory furnace. At firft a weak and light nitrous acid came over, which became more and more phlegmatic; then nothing but a phlegm of a red colour, fomewhat bitter, that was no longer acid, and which did not effervefce with alkalis. Having ftill increafed the heat a little, even fo as flightly to redden the bars on which the retort repofed, very penetrating white vapours began to pafs over, which were collected in the receiver, and which proved to be real *phofphoric* acid; in a ftate, however, half volatile. The operation being thought now complete, the veffels were left to cool; but on attempting to take out the liquor remaining in the retort, the greateft part was obferved to have become as thick as turpentine, and ftuck to the interior of the veffel, from which it was impoffible to pour it but by diluting it with diftilled water; and this prevented it's being weighed with exactnefs. The quantity of phofphoric acid obtained from 2 oz. 6 drachms of phofphorus by two pounds of nitrous acid may therefore be valued at eight or nine ounces; fuppofing the procefs not carried to the point of reducing the acid to the confiftence of thick turpentine, but only to that of a fomewhat thick firup. Such is the procefs which Lavoifier made ufe of to obtain the phofphoric acid, and in which the remaining two drachms of phofphorus were fuppofed to have evaporated.

Bergman. Other acids are faid to produce the fame effect; thus Bergman affirms, that if a piece of phofphorus be put into fome arfenical acid, it's whole furface foon becomes black, from the portion of arfenic that adheres to it in a reduced ftate: he does not, however, fpeak of the ftate of the liquor, but it appears to pafs in fome part to the ftate of an acid.

The ſame chemiſt, as well as Scheele, informs us, that the dephlogiſticated muriatic acid immediately converted ſome phoſphorus into a white ſmoke; but Morveau contradicts this aſſertion by his own experiments, ſaying, that the moſt concentrated dephlogiſticated muriatic acid in a liquid ſtate, even that taken under a concrete ſtate, in the manner of Berthollet, has no action upon phoſphorus at a medium temperature, nor even at 15° above the freezing point. Berthollet accounts for the difference between theſe chemiſts, by obſerving, that no action takes place between theſe ſubſtances without the aſſiſtance of *light*, but that when a piece of phoſphorus is added to dephlogiſticated marine acid and the mixture expoſed to light, it will acquire the properties of reddening the blue juices of vegetables, and of precipitating lime water, and forming a calcareous phoſphoric ſalt; and hence it appears that the phoſphorus imbibes the pure air of the dephlogiſticated acid, and is changed into phoſphoric acid; and indeed Morveau appears to admit the ſolution in the Encycl. Méth. art. *acide mur. dephlogiſt.* where he ſays, this acid inſtantly decompoſes phoſphorus, diſengages a white ſmoke, takes hold of it's phlogiſton, and returns into a ſtate of common aeriform muriatic acid. It is eaſy to account for the converſion of phoſphorus into the acid by means of the affinities. The acids give up their oxygen to the phoſphorus, and hence it takes it's acid ſtate; and the ſame may be effected, as Sage has ſhown, by adding ſolutions of copper, ſilver, and other metals, to phoſphorus; the metals are precipitated in their metallic ſtate, and the phoſphorus becomes an acid. Scheele.

4. A fourth method of obtaining the phoſphoric acid is, by ſeparating it from the ſaline or earthy bodies with which it is united. It is now well known that the phoſphoric acid is found united in urine to volatile alkali for 4th method.

it's bafis, forming the native phofphat of urine or fufible falt; but as it is prefent in urine with one or two fixed neutral falts, the phofphoric acid cannot be procured from it by heat in that ftate. When, however, this native phofphat is pure, the volatile alkali may be expelled from it by heat, by which means the phofphoric acid, being fixed, remains behind. Thus, according to Rouelle, when the fufible falt is deprived of every other neutral falt, and the liquor is put into a porcelain crucible, or any other proper evaporating veffel, if it be placed in an open fire or fand bath, and the liquor be then evaporated with caution, raifing the heat towards the end of the procefs, fo as to melt the phofphoric acid, it will be obtained in as tranfparent a ftate as the moft perfect and beautiful cryftal. The phofphoric acid thus obtained has been called the *acid bafis of native falt*; it is produced in a glacial ftate from the heat employed.

Rouelle.

It was likewife propofed to procure the phofphoric acid from another falt contained in urine; thus Hermbftadt advifes to digeft *Prouft's perlated falt* in vitriolic acid, which uniting with the mineral alkali, and by it's union forming a falt capable of cryftallization, leaves the phofphoric acid difengaged. The acid thus feparated may be further purified by heat from any adhering vitriolic acid.

Hermbftadt.

All chemifts, however, agreed that the acid extracted from phofphorus was much more pure, and hence that by combuftion was called by Prouft, *acide phofphorique par excellence*.

At the article *hard parts*, an account was given of feveral methods of procuring this acid from bones; from which it appeared, that on employing the vitriolic acid, the principle fault was the imperfect feparation of the calcareous earth; of which although the greater part unites with the vitriolic acid, and forms an infoluble felenite, yet enough remains in the acid lixivium to yield

an earthy ſediment upon evaporation, and to give ſome degree of opacity and of inſolubility to the vitreous acid prepared by this method. The preſence of the calcareous earth is proved by melting the vitreous acid with a ſufficient quantity of fixed alkalis, and lixiviating the melted maſs with water, upon which the calcareous earth will appear undiſſolved. In order to purify this acid, therefore, Rouelle recommended a method, founded on it's property of being inſoluble in ſpirit of wine. He broke the vitreous acid into ſmall pieces, and by addition of a little water reduced it to a gelatinous liquor, which he decanted clear from the earthy matter, and mixed with it 12 parts of ſpirit of wine. Next day the phoſphoric acid was found at the bottom of the mixture, of the conſiſtence of reſin of jalap recently prepared. By expoſing this acid to heat in a crucible, the moiſture and any vitriolic acid adhering to ſome remaining portion of ſelenite were diſſipated, and by urging the heat, a glaſs tranſparent as cryſtal was formed. Weigleb made uſe of another method, as obſerved at the art. *bones*; but a great improvement, according to Ker, has been made on the depuration of the phoſphoric acid by Bonvoiſin. Having found that evaporation and filtration were inſufficient to ſeparate all the earth adhering to the acid of bones, prepared by the vitriolic acid as deſcribed, he added a cauſtic volatile alkali, and obtained a copious precipitate, and when he could ſeparate no more by the cauſtic volatile alkali, he obſerved, that upon adding the ſame precipitate in a mild ſtate, ſome further precipitation enſued. He ſuſpected that the whole of the precipitates were *not ſelenite*, as has been generally ſuppoſed, and he found by experiment, that the precipitate formed by cauſtic ammonia was a *phoſphoric ſalt with a calcareous baſis*, and that the precipitate formed afterward by mild ammonia was a *calcareous earth*. He concludes, therefore, that after the

Bonvoiſin.

felenite has been precipitated in the common procefs, a portion of calcareous earth remains combined with the phofphoric acid, forming the phofphoric falt with bafis of calcareous earth; which, although little foluble in water, is readily diffolved in the acid of bones, or in other acids, as he found was the cafe. To feparate therefore the calcareous earth, the acid muft be faturated with an alkali, and the volatile is preferable, becaufe it may afterwards be expelled from the phofphoric acid by heat; and the mild alkali is preferable to the cauftic, becaufe the former decompofes the phofphoric falt of lime, fo that the whole of the acid remains in the lixivium, while the earth only is precipitated, whereas the cauftic alkali would precipitate the entire falt, being only held in folution by the fuperfluous acid. Bonvoifin continued the procefs, by evaporating the lixivium faturated with volatile alkali, and he obtained a cryftallized ammoniacal falt, which he melted in a filver veffel, the acid acting upon glafs or earthen veffels. The acid thus prepared is a compact glafs as tranfparent as rock cryftal, is acid to the tafte, foluble in water, and deliquefces on expofure to the air. It differs in fome refpect from the acid obtained by burning phofphorus, and is even purer, as Bonvoifin affirms, than this latter acid, which in his language is apt to be more or lefs phlogifticated: for the acid prepared by combuftion gives more red fumes when mixed and evaporated with nitrous acid, deftroys the red colour of a folution of manganefe in vitriolic acid (a fign of the phlogiftication), and is lefs difpofed to cryftallize when faturated with volatile alkali. The acid of bones, however, although depurated from calcareous earth by volatile alkali, is fubject to one fource of impurity, from which the acid obtained by combuftion is free; for Scheele has proved, that bones and other folid animal matters contain fome mineral alkali, from which the modes of depuration

juſt mentioned are, as Ker obſerves, perhaps incapable of freeing the acid obtained. The quantity, however, of this alkali is not very conſiderable, and may not affect the ordinary uſes of the acid.

Likewiſe, according to Fourcroy, the product obtained from bones by the vitriolic acid, as well as the reſidue of the phoſphat of ammonia decompoſed by fire, does not conſiſt of pure phoſphoric acid, not affording one fifth of it's weight of phoſphorus at moſt, but contains a certain quantity of the phoſphat of ſoda. If this ſalt remains mixed with calcareous phoſphat ariſing from a ſmall quantity of ſelenite, it uſually melts with the phoſphat, and forms a very hard opake glaſs which reſiſts the action of all menſtrua.

For a further account of obtaining this acid from bones the reader is referred to the inveſtigation of thoſe ſubſtances, and perhaps it might have been proper to have inſerted them here.

Vitrification of the acid.—When the native phoſphoric acid was obtained by Rouelle, it was converted into a tranſparent glaſs, and until Morveau had inſerted an account of the acid itſelf in the Encyclop. Méth, great ſuſpicions aroſe whether this ſubſtance, reduced to a ſtate of glaſs in the fire, really merited the name of acid; for it was aſſerted, that

Vitrification of the acid.

1ſt. The native phoſphoric acid not ſaturated by a baſis, or that has been deprived of the ammoniacal baſis by the heat of evaporation, preſerves all the properties of an acid as long as it is not reduced to a glacial form; as appears from the experiments of Berthollet on the change of blue paper in recent urine, on the precipitation of calcareous phoſphat which lime water produces in it, and from the obſervations of Rouelle on the effervеſcence that this acid makes with the volatile alkali added to the urine during it's evaporation.

2d. When the acid of native falt is in a ftate of glafs, it has neither the folubility nor the favour of acids; and according to the remarks of Prouft, it would appear to belong to a general and conftant law, that a fimple fubftance enjoying every power of acidity, ought alfo to have the favour, as a fign of that power. Bergman, in his differtation on the blowpipe, looks upon the native phofphat as a falt of three parts, *i. e. phofphoric acid*, foda and volatile alkali, to which he adds a fat gelatinous matter, but as it is diffipated by the action of the fire, it ought not to be included in the examination of the glafs which remains fixed. From this hypothefis, this glafs is the *phofphoric acid* that has loft it's volatile bafis, which is only imperfectly faturated by the mineral alkali; and, according to this chemift, it is on account of this excefs of acid that it fo readily attracts humidity from the air. Prouft, to whom the knowledge of that peculiar fubftance in urine is owing, which is foreign to the phofphorus, and which Bergman calls *acid of perlate falt* and Morveau *ouretic acid*, is of opinion that it is this fubftance which *faturates the phofphoric acid* in the infoluble glafs of the native falt; and Bergman appears to have adopted this hypothefis in the new edition of his Differtation on Affinities. Morveau, however, could not comprehend how one acid was able to faturate another; and how it only faturates it in a ftate exficcation, whilft in an aqueous ftate it lets it enjoy all the properties of a free acid. It is true, that Prouft does not give this fubftance the name of acid, and he obferves, that it turns the firup of violets green; but he allows, or rather eftablifhes the fact, that it performs the function of an acid, and that it acts upon alkalis as well as acids. On adopting the comparifon he propofes, of this fubftance with the concrete boracic acid or fedative falt, it may, according to Morveau, be imagined that it paffes eafily of itfelf to the ftate of glafs; that being in abundance, it covers and

defends the *phosphoric* acid, which is in less quantity, from the contact of all matter capable of acting upon it in the humid way; it may even be supposed, that the phosphoric acid is in part saturated with the soda, which the ouretic acid always carries along with it, and that this last, as being more weak, has been obliged to give it up, or perhaps to partake of it during the vitrification; but whatever probability this comparison gives to the system of Proust, it of course must fall, if it be found, that the pure *phosphoric acid*, exempt from all ouretic substance, isolated from any basis, likewise loses, at least to a certain point, the characters of an acid, on being pushed to a state of glass; and it must then be confessed, that these two effects depend on the same cause, which has not as yet been shown. For this purpose Morveau took some very pure phosphoric acid, extracted from phosphorus by a slow combustion; it was exsiccated by a gentle evaporation, and then put into a Hession crucible in a melting furnace, taking care to reverse another crucible upon it, to prevent any foreign matter entering, and a beautiful glass was obtained. This glass, exposed several months to the external air, was not dissolved, nor even had extracted any evident moisture. Having boiled some distilled water upon it, it very sensibly reddened blue paper; having decanted this first water, what was again put upon the same acid glass no longer changed litmus, and no dissolution took place, although the glass was boiled several hours in a large quantity of water. Here then, says Morveau, is a vitriform phosphoric acid, the acid properties of which have almost totally disappeared without being marked by the substance discovered by Proust, or any saturation. This glass, however, may return to the acid state which Morveau accounts for by it's passing through the state of phosphorus, by combining it with the phlogiston, and then let it inflame, the residuum being the regenerated acid,

he ſuppoſes it is the abſence of the vital air which is the cauſe of the inertia of the phoſphoric glaſs, and concludes, that the inſolubility of the acid extracted from the ſalt of urine, when puſhed to a glacial ſtate, is by no means a proof of the impurity of the acid.

Diſcovery of the properties of phoſphoric acid. Boyle.

In giving the hiſtory of the diſcoveries of the different properties of the phoſphoric acid, it will be neceſſary to begin with Boyle. This celebrated chemiſt found, that the water in which the phoſphorus, which he calls noctiluca, had been kept, to defend it from the air, had a ſtrong piercing taſte like that of ſea ſalt, but more pungent, as if brine was mixed with ſpirit of ſalt; on evaporation, it coagulated into a ſubſtance, ſometimes like a jelly, at other times like the white of egg, in conſiſtence, which ſubſtance was eaſily melted by heat. If, before the coagulated matter was too far waſted by the heat, it was ſuffered to cool a little, it had acquired a conſiſtence like melted reſin, or rather ſtiff birdlime, as it would draw out into threads a foot or more in length, one of which being held to the flame of a candle, did not take fire, but melted into little globules like glaſs, and likewiſe gave out a ſtrong ſmell like that of garlic; and being left all night in the air, it attracted moiſture exceedingly faſt, and was diſſolved into a liquor almoſt as ſtrong as ſpirit of ſalt. Putting this ſubſtance again over the fire as before, it appeared to become fixed, and afforded a multitude of ſhining exploſions, with evident flaſhes of light. In order to examine the ſaline part of the noctilucal matter, he ſuffered a little of it to diſſolve per deliquium into a clear liquor, and having dropped a little of it upon ſome ſirup of violets, it changed it to a fine carnation colour. It diſſolved ſome of the filings of copper without heat, and the ſolution was of a green and blue colour. It corroded red coral, and effervefced with dry ſalt of tartar, hence Boyle numbers it among the family of acid ſalts.

Margraaf carried his refearches much farther than Boyle, and proved in oppofition to the opinion of Stahl and his followers, who fuppofed it to be the acid of falt; that it had no connection with it, but that it was an acid *fui generis*. His experiments were made upon this acid produced from the burning of phofphorus, and likewife upon the fufible falt of urine which contains this acid in a free ftate; the laft was diffolved in between two and three parts of diftilled water; the firft he calls the *phofphoric acid*; the fecond, the *acid liquor*; with refpect to the firft, he found, that mixed with a folution of gold, no turbidnefs was immediately produced, but afterward a few fhining particles of gold fell to the bottom; diftilled by a ftrong heat, the refiduum was of a purple red colour. The acid had no effect upon fine filver filings, when ftrongly digefted with them: with a folution of filver, after fome time it became darkifh and blueifh, a very fmall portion fell down refembling black flocculi, and when diftilled, the refiduum looked like *luna cornea*. It feized upon the calx of quickfilver obtained by calcination, and changed it's yellowifh red to white, and by ftrong digeftion, to a black colour; but nothing was precipitated by the *oleum tartari per deliquium*. It produced an abundant white precipitate from a nitrous folution of quickfilver; this, on remaining in the cold was for the moft part taken up again, and only a fmall black heavy powder was left. It readily diffolved the filings of copper, and the folution was green; likewife iron, and formed cryftals with it. It had no effect on tin, till concentrated, it then acted fomewhat upon it. The fame happened with lead, but rather more; it however precipitated it of a white colour from it's folution in nitrous acid, and the precipitate was not rediffolved. It perfectly diffolved white arfenic, and a blackifh mafs remained after diftillation. It diffolved zinc very ftrongly, and with a ftinking fmell like that

Margraaf.

arifing from it's folution of tin. It united with *fal tartari*, and on evaporation, cryftals were produced that did not decrepitate. It effervefced ftrongly, and formed longifh pointed cryftals with volatile alkali. With refpect to the fecond, he found, that when ftrongly digefted with different metals, the following were it's effects. It had no action upon gold-leaf, even by boiling, and with the addition of nitrous acid; nor upon filver; the fineft copper duft was fcarcely affected by it. It however diffolved iron with effervefcence, and became at length turbid, glutinous, and of a fomewhat blueifh colour; it had but little effect upon tin and lead; it corroded zinc filings to a white powder, which, diluted with water and filtered, were precipitated by oil of tartar. Pulverized regulus of antimony was, during digeftion, in part diffolved, as appeared from it's precipitation by oleum tartari; it did not affect bifmuth; it gave the blue calx of cobalt a red colour. This *phofphoric falt*, however, had a much ftronger action upon metallic bodies in the dry way; and as it's ammonia efcapes by heat, the effects it had may be looked upon as thofe of the acid. Melted with pure gold it formed a purple fcoria; with filver filings, an opake fcoria; with copper the fcoria was greenifh, it likewife gave this metal a whiter colour, and rendered it more brittle; with iron, a glaffy fcoria of metallic appearance, which when broken was of a greenifh yellow colour; during the fufion fparks of phofphorus were conftantly emitted, which Margraaf accounts for, from the acid uniting with the inflammable principle of iron; the metal was femivitrified and fpungy in texture. With tin the fcoria was milk white, and the metal was become foliaceous in texture, fhining, and refembling zinc in it's fracture; with lead the effects were the fame; phofphoric fparks were emitted from both. It diffolved the calx of quickfilver precipitated from aqua

fortis by oil of tartar; the mafs was whitifh, but not clear, and when diffolved in diftilled water, a yellow powder fell to the bottom, which by heat was converted into quickfilver; a drop of the remaining clear water immediately made a white fpot upon a clear copper-plate. It gave regulus of antimony a beautifully fplendid and radiated appearance, and the fcoria was fomewhat opake. Bifmuth was but little changed by it. A moderate heat applied to a mixture of it with zinc produced a great deal of phofphorus, and beautiful phofphoric flames; the remainder was a gray vitrified fcoria; expofed with white arfenic to a ftrong heat, the mafs on being left in the open air deliquefced, was of a fnow white colour, and when cold moderately tranfparent. Expofed to a red heat with fulphur, the laft fublimed, whilft the falt remained unchanged in a perfectly clear fufion. With cinnabar no change of any confequence was likewife obferved, it alfo fublimed; with manganefe it became a femitranfparent mafs, and yellowifh in fome parts, but did not deliquefce; the fides of the crucible, and around the mafs itfelf, were of a purple red; with the calx of filver, the fcoria was whitifh, but not clear, with a yellowifh fhade, and very little was reduced; with *crocus veneris* a beautiful green fcoria was produced, in which all the copper was diffolved; with *crocus martis* it gave a dark brown fcoria; with calx of tin, a beautiful white mafs; calx of antimony afforded a whitifh fcoria; calx of bifmuth, a yellowifh green mafs; flowers of zinc afforded the whiteft mafs, it was femitranfparent, refembling opal. All thefe, except the filver, formed mixtures, that did not deliquefce or melt. With chalk it formed a femitranfparent body, like glafs, and not deliquefcent; with finely pulverized marble, it melted fo thin, as to run out of the crucible, a fmall remnant only was left, vitrified; the fame with refpect to alabafter; with fpanifh chalk it gave

a ſomewhat porous maſs, the fracture of which was ſhining and ſemitranſparent; with a Saxon topaz, a beautiful opal coloured maſs, and not deliqueſcent; with flint, the ſame, but deliqueſcent; with fine white clay, the ſame as Spaniſh chalk; with fluor ſpar a ſemitranſparent maſs. Diſtilled with oil of vitriol, the mixture on boiling became browniſh, and then turbid and white; at a ſtronger heat the oil of vitriol came over, and the remainder was opake, white and deliqueſcent; with ſtrong ſpirit of nitre, the latter came over, and the remainder was tranſparent like borax-glaſs; with *ſpiritus ſalis*, the ſalt being fixed, nothing remarkable was obſerved; with pure ſalt of tartar, nothing aroſe, although expoſed to a red heat; being diſſolved in diſtilled water and cryſtallized, the cryſtals were long and had an exceſs of alkali, hence the neceſſity of repeated ſolution and cryſtallization. Expoſed to the ſtrongeſt degree of heat with pure vitriolated tartar, a heavy acid droſs came over which effervesced with fixed alkalis, and when cryſtallized, reſembled vitriolated tartar. The remainder was white and fuſed, difficultly cryſtallizable, and differed from vitriolated tartar, likewiſe, in being eaſily ſoluble in a little water. Pure nitre being expoſed with it to a ſtrong heat, red vapours aroſe, a proof that this ſalt expels the nitrous acid from it's alkaline baſes; the remainder was of the colour of peach flowers, but had not ſo perfectly become fuſed, as that with vitriolated tartar, and was more difficultly ſoluble in water. On evaporation the cryſtals were longiſh, reſembling thoſe obtained from ſalt of tartar. They did not detonate on hot coals, but by the blow-pipe became a round maſs, like that from ſalt of tartar which became opake on cooling. With common ſalt, the ſame as laſt, the ſpirit of ſalt came over, and the remainder was milk-white, eaſily ſoluble in water, and afforded cubic cryſtals, which decrepitated on red hot coals; there was, however, ſome difference; with ſal ammonia, no change

took place; with finely powdered borax, the fuſion was ſo ſubtile as to pierce the ſides of the crucible; the little remaining had glazed the bottom of the crucible, but did not attract moiſture. This ſalt diſſolved in two parts of water and mixed with lime water was left to evaporate on a moderately warm furnace, and during the evaporation (from 1 quart to 10 ounces) a great quantity of fine white porous earth had been depoſited at the bottom; this filtered and dried was not fuſible, but efferveſced with aqua fortis; the filtered liquor afforded a yellowiſh radiated ſalt, that did not deliqueſce; this ſalt diſſolved in two or three parts of water, when it was perfectly clear, and precipitated the following earths from their ſolutions: flint diſſolved by fixed alkalis; calcareous earth from acid of ſalt of a white colour, which was remarkable for being for the moſt part as birdlime after edulcoration; and the earth of alum. It did not precipitate gold from aqua regia, but ſilver fell down of a white colour from the nitrous acid. It precipitated copper from nitrous acid, in the form of a white powder, often likewiſe in the form of a green oil, and oftentimes had no effect, which aroſe from the proportions of the water. Iron fell from the nitrous acid likewiſe; and as a white powder from ſpirits of ſalt; the precipitate was tough in the heat, but boiling water entirely diſſolved it. Lead fell down from nitrous acid of a white colour, as well as tin diſſolved in aqua regia, but this laſt metal was not precipitated from the vitriolic acid. Quickſilver from the nitrous acid and biſmuth equally produced a white powder; after ſome time it precipitated zinc from the nitrous acid. Such are the experiments which Margraaf made upon the phoſphoric acid, and later obſervations have confirmed ſome and added to others.

Taſte of phoſphoric acid.

With reſpect to it's taſte, Leonhardi thinks it reſembles that of vitriolic acid, and ſhows no particular ſharp-

nefs, although de Laffone and Cornette have defcribed it as cauftic.

Specific gravity. It's fpecific gravity according to Morveau cannot be determined in a ftate of fluidity, as it may be dephlegmated to drynefs; in a vitreous ftate Crell found it to water as 3 to 1, but as his acid had not been in a ftate of phofphorus, it was not perfectly pure. It's concentration even varies in a liquid ftate, from it's fpontaneous deliquefcence; the ftrongeft which Morveau faw, was 1,417, another time only 1,306. According to Briffon, the fpecific gravity of a phofphoric acid, a cubic foot of which weighed 109 lb. 3 drachms $11\frac{2}{3}$ grains, was to diftilled water as 15575 to 10000. But de Laffone and Cornette mention fome of this acid that was to water as 19 to 8.

With water. Thefe two laft chemifts have alfo obferved the heat produced on mixing this acid with diftilled water. With an acid of the confiftence of oil of vitriol they raifed the therm. (Reaum.) 15°; with another acid of a fpecific gravity to water as 19 to 8, they raifed it from 13° to 34°, and another time, when two parts of this acid were added to one of water, 4° more.

Nitrous gas. Prieftley obferved, that this acid was foon faturated with red nitrous vapours, or nitrous gas, and then became of a deep indigo colour.

Potafh. The falt it forms with potafh has been called tartarus phofphoratus, alkali vegetabile phofphoratum. It cryftallizes without difficulty; when expofed to heat in clofe veffels it is not decompofed, but becomes an opake vitreous mafs, foluble in water. It is decompofed by lime water, and by felenite folutions, the phofphoric acid uniting and precipitating with the earth, forming a phofphoric falt of lime. Although it decrepitates on the coals like common falt, yet it did not with the blowpipe according to Margraaf, but was converted with borax into a

tranſparent vitreous body. It does not communicate, as well as other phoſphoric ſalts, any colour to the flame of alcohol, although it contained a few reddiſh parts. It is decompoſed by fluoracid and a fluat of potaſh containing ſilex is precipitated. It is not decompoſed by the acid of arſenic, but is in part by that of tartar. Silver precipitates it in the form of a fine white powder, by double affinity; quickſilver, of a yellowiſh colour, and lead, of a darkiſh white powder.

By a ſmall ſuperabundance of acid when united to ſoda this ſalt is ſaid to poſſeſs the peculiar property of being fixed in the cold and fluid at an evaporating heat, without the aid of water. Limewater decompoſes it's aqueous ſolution; alcohol, acids and the above mentioned metals, act upon it as upon the phoſphat of potaſh, but the acid of tartar does not decompoſe it. It has been called, ſal phoſphoreum minerale, ſel phoſphorique à baſe de l'alcali minéral; when properly ſaturated, it effervefces in the dry air like other ſalts with baſis of ſoda, and being free from any unpleaſant taſte, has been of late years introduced into medicine as a purging ſalt. Soda.

Dr. Pearſon gives the following proceſs for preparing this phoſphat of ſoda. Diſſolve in a longnecked matraſs 1400 grains of cryſtallized mineral alkali in 2100 grains of water, at the temperature of 150° of Fahrenheit's ſcale. Add gradually 500 grains of phoſphoric acid, of a ſpecific gravity to water as 1,85. Boil the liquor ſome minutes, and while it is boiling hot, filtrate it and pour it into a ſhallow veſſel; let it remain in a cool place, and cryſtals will continue to form during ſome days. From the above quantities of the materials, he has obtained from 1450 to 1550 grains of cryſtallized ſalt. The cryſtals are ſolids contained within ſix rhomboidal faces, of which the acute angles are 60° and the obtuſe 120°.

United with ammonia it forms the ſal ammoniacum Ammonia.

phofphoreum, or fel phofphorique ammoniacal, the folution of which is likewife decompofed by lime water. According to Lavoifier, it's cryftals refemble thofe of alum, and are eafier foluble in warm than cold water; they require from five to fix parts of cold water for their folution, and are not deliquefcent. According to Wenzel the ammonia is to the phofphoric acid in them as 8 to 3. This falt fwells when expofed to the fire, but although it is decompofed, the fixity of it's acid prevents it's fublimation. It is found ready formed in urine, and is the faline fubftance from which phofphorus is obtained in the procefs for preparing it from that animal liquor; for the volatile alkali efcapes by heat, leaving the phofphoric acid at liberty to combine with the inflammable matter, and to form phofphorus; whereas the other phofphoric falt obtained in urine, which has juft been mentioned under the name of phofphat of foda, is incapable of decompofition by charcoal.

Lime. With lime, according to Wenzel, it forms a gummy mafs, and a few cryftals, but the greater part is in the form of a gritty powder which finks to the bottom. In fact, fays Ker, this compound is almoft infoluble in water, and the part which remains fufpended, or appears in cryftals, as Wenzel defcribes, is merely diffolved by the fuperfluous acid. Lime has the greateft affinity to the phofphoric acid, which takes it from the nitrous, muriatic, fluor acid, arfenical and acid of ants, lactic and acids of lemons and vinegar; even in the dry way, from the fluor acid. This almoft infoluble falt is called fal calcareum phofphoreum, calx phofphorata, fel phofphorique calcaire, and is prepared the beft from ftrong limewater or chalk and the phofphoric acid. From it's difficult folubility in water and confequent difficult cryftallization, the real ftate of it's cryftals cannot be determined, but from their changing the tincture of litmus to

a red, they appear to have a ſuperabundance of acid (calcareous phoſphit.) It is, however, ſoluble in the nitrous and vitriolic acids, and is acted upon, with reſpect to the ſeparation of it's acid, in the ſame way as the earth of bones. Cauſtic alkalis have no effect upon it either in the moiſt or dry way; the precipitate of phoſphat of lime, ſuperſaturated with the acid, and made ſoluble by cauſtic alkali, is phoſphat of lime; mild alkalis, according to Lavoiſier and Morveau, decompoſe it, both ways, by means of double affinity, although in the dry way, from the ſurplus of alkali, very imperfectly. Mild volatile alkali likewiſe attacks the phoſphat during the digeſtion, ſo as to produce a phoſphat of ammonia; but it does not decompoſe it's ſolution ſo well by a quick precipitation, becauſe the phoſphat of lime becomes inſoluble by depriving it of the ſuperabundant acid, and falls down undiſſolved to the bottom. A ſolution of ſilver is precipitated by it, of a dirty gray, but by degrees becomes reddiſh, and a ſolution of quickſilver in the form of a white powder. It does not colour the flame of alcohol.

Morveau combined this acid with ponderous earth, by adding it to a ſolution of this earth in marine acid, upon which the phoſphoric acid ſeparated the earth from it's ſolvent, and formed with it an inſoluble precipitate. It has been called terra ponderoſa phoſphorata, phoſphoreum barytatum, phoſphate de Baryte. It is without taſte, and in a ſtate of powder. Made ſoluble in water by means of a ſurplus of phoſphoric acid, it is more or leſs decompoſed by the acids of vitriol, ſugar, amber, and fluor, and perhaps, alſo, as Bergman ſays, by mild alkalis. Barytes.

With magneſia, this acid forms, according to Wenzel, beſide a very difficultly ſoluble powder, and a gummy maſs, ſome ſmall ſhining cryſtals, inſoluble in nitrous acid, and which melt in the furnace to a porcelane-like ſubſtance. Magneſia.

According to Bergman, ſimilar cryſtals ariſe when the acid is added to a ſolution of magneſia in vinegar. Lavoiſier obtained by ſpontaneous evaporation, fine, flat, ſmooth needles, a few lines in length, cut obliquely at both ends, and which, when expoſed to the air, fell in pieces; they reſembled thoſe that gypſum gives by a long and almoſt imperceptible evaporation. This ſalt is called ſal phoſphoreum magneſiæ, magneſia phoſphorata, ſel phoſphorique de magneſie; or, according to Weigel, bitterphoſphorſalz.

This ſalt is alſo obtained by the decompoſition of all magneſian ſalts, except thoſe of the acids of fluor and ſugar. By alcohol, it's ſolution is rendered turbid. All mild alkalis decompoſe it by digeſtion carried to a boiling heat, and the fixed on calcination. Limewater precipitates magneſia from it's ſolution, and the precipitate falls with phoſphat of lime. Gypſum the ſame by double affinity.

Argile. The phoſphoric acid (according to Wenzel) eaſily unites with pure clay when digeſted upon it, forming an inſoluble ſaline powder, and a clear fluid ſolution, which, by evaporation, yields a gritty powder, and at laſt, a matter reſembling gum arabic, which, by heat, becomes a tranſparent glaſs. This has been called alumen phoſphoreum, argilla phoſphorata, phoſphate d'alumine, alaunerdichtes phoſphorſalz. The acid of vitriol, cauſtic, and mild alkalis, limewater, and magneſia eaſily decompoſe it. Vinegar even takes the argile from the phoſphoric acid, according to Bergman.

Silex. This acid has not any ſenſible effect upon ſilicious earth, in the humid way, although it has been obſerved by Rouelle to attack glaſs.

In the dry way, Ker obſerves, that this acid acts upon all earths. Margraaf, as before obſerved, expoſed to heat mixtures of three parts of acid with one part of Saxon topaz, flint, clay, and chalk, and obtained from

each of these earths, vitreous masses, more or less transparent: of all these glasses that made with flints was the only one which seemed to be deliquescent.

Lavoisier found, that leaf-gold, which he had changed into a very fine purple powder by trituration with sugar, and washing it with water, lost nothing of it's weight after being twelve hours boiled with dilute phosphoric acid, and that an alkali precipitated nothing from it. According to Margraaf, the addition of nitrous acid did not render it capable of dissolving this metal, which shows, that Stahl's idea of the identity of this acid with the marine is not well founded. Gold.

According to Wenzel's experiments, the phosphoric acid seized upon some silver that had been produced from luna cornea, and actually in part dissolved it. Some precipitated calx of silver, on digestion with this acid, was coloured black; and although there was no appearance of solution, yet after the evaporation of the clear liquor, a saline substance remained, which, by the blowpipe, was melted to a dark, dirty, opake glass. The edulcorated black powder exposed to a red heat, became yellow, and by a stronger heat, part was reduced, and part vitrified, of a dark colour. Common salt precipitated the solution, bluish; likewise the alkalis and metals precipitate silver from this acid. As this acid does not precipitate this metal from it's solution, of itself, Leonhardi thinks, that in Margraaf's experiments, where the black flocculi of silver were deposited, it was owing to some phosphorus that was present, as that substance precipitates many metals in their metallic state. Silver.

The solution of the calx of copper, precipitated by an alkali, in this acid, affords, after evaporation, a green transparent mass, resembling gum arabic, which melts, by the blowpipe, to a perfectly dark opake glass. By fixed alkalis, the solution, according to Wenzel, is pre- Copper.

cipitated green, but by zinc and iron, in it's metallic ſtate. It does not precipitate the vitriolic, nitrous, or muriatic ſolution of copper, but precipitates that of verdigris. The phoſphoric acid prepared from the aſhes of bones containing a ſaline matter, on being fluxed with $\frac{1}{30}$ of the calx of copper, and precipitated from it's muriatic ſolution by an alkali, the compound is a ſea green glaſs; and it precipitates in the moiſt way, copper diſſolved in muriatic acid, vinegar, or the acid of fat; from the two laſt acids, of a white colour. Lavoiſier found metallic copper as ſoluble in the phoſphoric acid as gold; that the union of the calx of copper was poſſible, but weak, and not fixed; and he employed this acid to ſeparate copper from iron. Lavoiſier attributes this inaction of the acid upon the metal, to it's great affinity to it's pure air, which prevents it's parting with it to the metal. Margraaf, it is evident, therefore, differs from the French chemiſt; and Ker obſerves, that probably this difference between the two illuſtrious chemiſts may be reconciled by ſuppoſing, that this acid is incapable of acting *directly* on copper, but that by *abſorption of air* from the atmoſphere, it becomes capable of diſſolving it in the ſame manner as vegetable acids can.

The copper which this acid diſſolves, is retained ſo weakly, that it may be ſeparated by adding gold to the ſolution, which metal attracts the copper from the acid.

Iron. From what has been already ſaid of this acid with iron, it appears that it is capable of uniting with it in two proportions. According to Margraaf, the compound is a cryſtallizable ſalt; but according to Morveau, only a white magma ſomewhat deliqueſcent. The difference of theſe reſults, Ker obſerves, depends on the different degrees of ſaturation of the acid; for Wenzel relates, that this acid makes a clear ſolution of iron, and by evaporation, cryſtals may be formed that do not de-

liquefce in the air, and which, by heat, are changed into a garnet coloured glafs; but that, if the folution of the iron be continued till the acid is faturated, the whole compound of acid of iron will fall to the bottom, and become a dry adhefive mafs, infoluble in water, and foluble in fpirit of vitriol. From the folution of this precipitate in dilute vitriolic acid, the iron may be feparated by lime, in it's metallic ftate; by alkalis, in form of a gray powder, which is cryftallizable on account of a portion of phofphoric acid it retains. Lavoifier received only a greenifh, faline fubftance, foluble in water, and by further faturation, during the folution and evaporation, a grayifh white precipitate.

Of all the compounds of this acid with metallic fubftances, that with iron is the moft interefting, as it is faid to be owing to a mixture of the phofphoric acid in certain ores of iron, that this metal acquires the quality called *cold-fhort*, which, by diminifhing it's ftrength, renders it lefs ufeful.

Some years ago, two excellent chemifts, Meyer and Bergman, obferved, about the fame time, that when *cold-fhort iron* was diffolved to faturation in vitriolic acid, the folution, particularly after having been diluted with water, let fall a *white precipitate*, which being edulcorated, and melted in a crucible with powdered charcoal, gave a white, brittle, and fufible regulus. A portion of this regulus being melted with a quantity of good iron, gave this iron a cold-fhort quality. Hence it was inferred that this metallic fubftance was the caufe of this vicious quality to which the iron made from certain ores is fubject; and Bergman, as Ker obferves, claffed it, rather too haftily, as a new femimetal, to which he gave the name of *fiderum*, apparently from it's relation to iron, being derived from the Greek word σίδηρος, fignifying that

metal; it has been called *fiderite* in Englifh and French, and waffereifen by the Germans.

This fubftance, however, did not long enjoy it's new diftinction as a femimetal; for it's difcoverer, Meyer, and alfo Klaproth, perceived it's fimilarity to the compound made from iron and phofphoric acid. The latter chemift further difcovered, that the fubftance called *native Pruffian blue* was of the fame compofition. But although the refemblance between the fiderite and the artificial compound of iron and phofphoric acid, gave ftrong reafon to believe in their identity; yet the proof by analyfis was not obtained till Scheele added this to his former difcoveries. Although other acids have a ftronger affinity to the iron than the phofphoric, yet it was not poffible to feparate this acid, becaufe thefe acids may actually decompofe the fiderite; yet the phofphoric being the moft fixed in the fire, the other acids will be expelled by heat, and leave the iron again with the phofphoric acid. Scheele, therefore, had recourfe to the effect of a double affinity. He prepared a quantity of the white precipitate of the fiderite, by diffolving cold-fhort iron in dilute vitriolic acid, as Meyer and Bergman had done. He boiled this white matter in a fixed alkaline ley, by which he feparated an ochre of iron. As the filtrated lixivium contained a fuperabundance of alkali, he faturated it with nitrous acid. He obferved, that on dropping a little of this faturated liquor to lime water, an earthy powder, fimilar to the earth of bones, was precipitated, which indicated the prefence of the phofphoric acid. He then poured into the faturated lixivium, by degrees, a folution of mercury in nitrous acid, till no more mercurial precipitate was thrown down. This precipitate, which was a compound of mercury and the phofphoric acid, he mixed with charcoal powder, and by

diſtillation, obtained, firſt, the revived quickſilver, and then a phoſphorus. He thus aſcertained the exiſtence of the phoſphoric acid in the white calx, which precipitates from ſolutions of cold-ſhort iron, and he confirmed by this analyſis the ſynthetic reſults of Meyer and Klaproth. He had previouſly aſcertained the juſtneſs of this mode of analyſis, by trying it on an artificial compound of iron and phoſphoric acid. It is evident, as Ker obſerves, that in Scheele's experiment, the alkali decompoſed the ſiderite, ſeparated the iron, and remained united with the acid in the lixivium; that by adding the ſolution of mercury to this lixivium (previouſly ſaturated by nitrous acid, in order to engage the ſuperfluous alkali) the phoſphoric acid was combined with the mercury, and this compound being inſoluble, was precipitated, while the alkali united with the nitrous acid. The volatility of mercury by heat gave an opportunity of diſengaging it from the acid, while this acid, uniting with the charcoal, formed phoſphorus. By the ſame proceſs, Scheele aſcertained the preſence of the phoſphoric acid in the *native Pruſſian blue*.

Lelievre has diſcovered, near Limoges, a perfect native phoſphat of iron, *i. e.* the iron is entirely ſaturated by the phoſphoric acid; it is of a red brown colour, is ſemitranſparent, and has a foliated texture.

Even when concentrated, this acid only acts weakly upon tin; it corrodes it, and a very unpleaſant ſmell is emitted, according to Margraaf; at the ſame time, the phoſphoric acid, which has remained upon this metal, neither ſuffers any precipitation by alkalis, nor is there any perceptible loſs of weight in the metal itſelf. There is no precipitation even by tin, in a ſolution of phoſphat of copper. The calx of tin is in part diſſolved in this acid, but in ſmall quantity; but it is in part ſo changed as to be very vitrifiable in the fire, according to Wenzel. Tin.

Quickſilver. According to Margraaf, this acid has no action on the calx of mercury precipitated by an alkali. Morveau found, that when the phoſphoric acid was digeſted upon quickſilver, almoſt to dryneſs, then diſſolved again and filtered, on the addition of an alkali, a whitiſh appearance was produced, but by evaporation, a browniſh magma was obtained; yet, neither could the vitriolic acid, nor ammonia, nor even lime water detect the preſence of mercury in it. Lavoiſier digeſted diluted phoſphoric acid with pure quickſilver for ſome months, in the cold, without any effect.

Arſenic. According to Margraaf, this acid perfectly diſſolves white arſenic; the evaporated ſolution affords a black maſs, which is tenacious, and for the moſt part volatiliſes on expoſure to heat. It has very little or no action on the regulus; according to Morveau, a drop of alkali precipitates from the acid digeſted upon it a white earthy precipitate, but the ſecond drop rediſſolves it.

Zinc. According to Wenzel, the phoſphoric ſolution of zinc is incapable by evaporation of being brought to cryſtallize, as it affords only a white tranſparent maſs, ſimilar to gum arabic, which before the blowpipe is converted into a tranſparent, eaſily fuſible glaſs. This phoſphoric ſolution is precipitated by alkalis to a white vitrifiable powder. The uncryſtallized maſs, according to Morveau, is eaſily diſſolved by water, without decompoſition.

Crell, reflecting on Scheele's method of ſeparating the phoſphoric acid from it's union with fixed alkali, by means of the double affinity of the nitrous acid to the alkali, and of mercury to the phoſphoric acid, contrived a new proceſs for obtaining phoſphorus from bones, viz. by melting burned bones with fixed alkali, lixiviating the melted maſs, ſaturating the filtrated lixivium with nitrous acid, adding to the ſaturated liquor a ſolution of mercury in nitrous acid, till the precipitation

ceafed; and laftly, by adding to the precipitate fome powdered charcoal, and diftilling the mixture till the mercury firft came over, and then the phofphorus. He propofed afterward to fubftitute, for the fake of cheapnefs, *vitriol of zinc* to the folution of mercury. But Weftrumb affirms, that this fubftitute did not fucceed well, little or no phofphorus being thus produced. From the experiments he made on this fubject, Weftrumb concludes, that vitriol of zinc is not capable of decompofing completely the phofphoric falt with bafis of fixed alkali: 2d. that the phofphoric acid united with zinc cannot be eafily feparated from this bafis, but that they rife together in the form of flowers: 3d. that this acid having a ftronger affinity to zinc than to any other metallic fubftance, is ftill lefs capable of being feparated from this metal by addition of inflammable matter, than it is from iron, when united with this latter metal in the fubftance called *fiderum*. Crell remarks, upon Weftrumb's conclufions, that it has been affirmed by other authors, that phofphorus has been actually obtained by diftilling compounds of phofphoric acid and zinc; and that even Morveau had obtained a *little* by trying the procefs which Crell had fuggefted, although not enough to induce him to think favourably of the procefs itfelf. According to Ker, in order to explain the difference of the refults which occurred to different chemifts, it is neceffary to have recourfe to one of the moft general and ufeful maxims in chemiftry, viz. that bodies combine with each other in certain different proportions, and that their affinity to each other varies in ftrength in the differently proportioned compounds. Thus when zinc and iron are directly combined with phofphoric acid, the compounds formed contain a much larger proportion of acid than the precipitates do, which are depofited fpontaneoufly from the folutions of thefe metals in that acid, or from

the folutions of other phofphoric falts, by adding a folution of iron or zinc in vitriolic or nitrous acids.

If then the former compounds of phofphoric acid and iron, in which the acid abounds, be mixed with charcoal, and diftilled, the fuperabundant acid will furnifh phofphorus. But when the precipitates are treated in the fame manner, the fmaller proportion of acid adheres too ftrongly to thefe metals to yield to the action of the charcoal. Hence neither Crell's procefs with the zinc precipitate could fucceed, nor can phofphorus be obtained from *fiderite* and charcoal.

Antimony. In the moift way, according to Morveau, the phofphoric acid diffolves a little of the regulus of antimony, but more of the calx precipitated by an alkali. From this folution, alkalis and zinc precipitate an afh-gray powder, eafily vitrified; and by evaporation, a dark green matter is obtained, very tenacious, which foams on expofure to heat, and is converted into a white tranfparent glafs. What remains of the undiffolved calx melts, according to Wenzel, before the blowpipe, into an opake, white glafs.

Bifmuth. According to Morveau, this acid attacks bifmuth, and it diffolves in part the calx precipitated by an alkali, in fuch a manner, that from the clear folution cryftals arife, that are fixed in the air, and foluble again in water; they foam in the fire, become black, and at laft are volatilized; it, however, in part changes it to a faline powder, which is not acted upon by nitrous acid, is not fufible at the heat in which copper melts, and after fome fmoke, is baked to a light gray porous fcoria.

Alkalis and zinc precipitate, according to Wenzel, the cryftals of the phofphat of bifmuth, in a gray powder, eafily vitrified.

Cobalt. According to Morveau's experiments, this acid had no action on the regulus of cobalt, even in the heat; but it

attacked the calx at the boiling point, and formed with it a deep wine-coloured ſolution. Crell obſerved, as he digeſted the ſaline ſubſtance (containing this acid) obtained from the earth of bones, at firſt, a yellow ſolution to ariſe, which changed to a white, then violet, and at laſt to a purple coloured hard maſs. Precipitated cobalt with the above phoſphoric acid from bones, afforded in the cold a colourleſs ſolution; but on boiling, it became as fixed as the regulus of cobalt. By ſolution with water a reddiſh fluid was produced.

Pulverized mangaueſe, according to Scheele, although it diſſolved in ſmall quantity in this acid, yet afforded at laſt a ſaturated ſolution. According to Morveau, the ſolution of the calx of this metal appeared red; but by ſtanding in the air became as white as the reguline ſolution; again became red on being filtrated upon the calx, and again loſt it's colour on expoſure to the air. Morveau accounts for this change of colour, from the affinity of the calx to the principle of inflammability. Manganeſe.

We are informed by Cornette, that weak phoſphoric acid has little or no action upon oils. That which was to water as 19 to 8 mixed with an equal quantity of æthereal diſtilled, or expreſſed oils, of a ſimilar temperature with itſelf, at firſt fell down to the bottom, without effecting any change; but on being ſtirred they became thicker, darker, and more fixed; while it became ſomewhat reſinous, and in boiling water, in which it was very ſoluble, appeared milk white. Mild drying oils produce leſs heat with it, become at firſt likewiſe thickened by it, but on ſtanding, ſeparate in a thinner ſtate than before, and are made by it ſoluble in alcohol. It, however, retains ſomething of the oils, which is evident from it's milk-white ſolution in water. The colour, conſiſtence, and heat of mild fat oils are leſs changed by this acid, and they do not become ſoluble in alcohol, in conſe- Oils.

quence. No oil is diftilled with this acid that is butyraceous, and no foap is produced with it.

According to Morveau, this acid has an evident effect upon oils; mixed in equal parts with olive oil, it becomes, by agitation alone, of a fawn colour, which remains even after the feparation; this fhade ftill increafes, if the mixture be digefted, the acid occupying the bottom part is thickened, the layer of oil in contact with it becomes black and carbonated, the whole acquires a ftrong odour, refembling that from a mixture of ether and oil of turpentine; the acid preferves this odour, even after having been diluted with a large quantity of water, and filtrated; and the oil ftill retains it after diftillation. Thus, thefe two fubftances are reciprocally changed, and the academicians of Dijon were right in obferving, that this circumftance ought to be attended to, as being able to caft fome light on Dippel's oil, which is, perhaps, only the product of the ethereal union of the phofphoric acid with the effential animal oil.

Alcohol. Margraaf has obferved, that the phofphoric acid is infoluble in fpirit of wine; this has been confirmed by Wenzel; and Rouelle, as before obferved, has attempted, from this property, the purification of this acid. Wenzel places the acid falt of urine in the clafs of fubftances infoluble in fpirit of wine. De Laffone and Cornette, fay, that it coagulates the phofphoric acid as well as the lymph of animals; and Scheele, in his Differtation on Ether, indicates fpirit of wine, as a very good vehicle to take away, by diftillation, the phofphorus that may happen to remain in this acid; yet, a long time ago, the academicians of Dijon obferved, that from the mifcibility of thefe two fluids, there was always a lofs on purifying the phofphoric acid according to the procefs of Rouelle. This obfervation has been confirmed by Lavoifier, who mixed in different proportions,

ſpirit of wine and *phoſphoric acid, ſometimes concentrated, at other times phlegmatic*; and who affirms, that the effects are much the ſame as thoſe ariſing from the mixture of this acid with water; that *heat is equally produced*, and that the thermometer riſes nearly to the ſame degree. Laſtly, in a memoir publiſhed in 1783, the Duke de Chaulnes recommends the purification of the native phoſphat of urine by ſpirit of wine; and aſſerts, that the acid, which remains in the retort after the diſtillation of the impure ſalt, is deliqueſcent; and that what is purified leaves an acid, which preſerves it's tranſparency and ſolidity in the air. From the difference of theſe chemiſts, Morveau is of opinion, the queſtion would be difficult to determine, if the greater or leſs ſtate of purity of the acid they uſed was only conſidered, that which Lavoiſier and the academicians uſed being prepared by the combuſtion of phoſphorus. But he thinks it very probable, that it ſtill contained ſome undecompoſed phoſphorus; and it is well known, that phoſphorus is ſoluble in ſpirit of wine, although it may be ſaid, that ſo ſmall a quantity could not ſerve as an intermedium to ſo large a portion of acid. Morveau, therefore, concludes, that the phoſphoric acid does not form an exception to the general law, which ſubmits all acids to ſolution by ſpirit of wine, only in proportion as they loſe their acid characters, whether by taking a baſis, or by being deprived of a portion of their acidifying vital principle, which brings us back to the hypotheſis of the reduction of this acid to it's radical vitriform principle.

We are informed by Lavoiſier and Cornette, that the phoſphoric acid with ſpirit of wine produces heat very evidently; but that this acid does not, when ſtrong and diſtilled with ſpirit of wine, afford any ether, but a fluid which approached near it in it's inflammability, according to Morveau. It had an unpleaſant ſmell, which, as well

as it's manner of burning, proceeded from a portion of phofphorus, to be found by means of adding water to the extracted alcohol. The obtaining however of a phofphoric ether is faid not to be void of all hope; for not only Weftrumb obtained with a phofphoric acid (extracted from bones, purified by Wiegleb's method from the calcareous earth by means of fpirit of ammonia, and from volatile alkali by means of heat) and manganefe, diftilled with fpirit of wine, a fpirit that fmelled very like quinces, and which on rectification left a white earthy mark in the retort; and by inflammation upon water, a refidue refembling garlick in fmell; but Cornette likewife found, that on diftilling a mixture of phofphoric acid and tartarized alcohol, a fluid firft came over that fmelled ftrongly of garlick, then one that was ftill ftronger having the fmell of ether, which tafted very differently from fpirit of wine; and as he extracted frefh alcohol repeatedly from the acid refidue, that which came over fmelled always more aromatic; even after he had mixed all the fluid that came over with fixed alkali, a red matter fell down during a lively effervefcence, that was difficult of folubility in water, and not cryftallizable, and which he calls (*fchweflichtes*, or *olichtes phofphorfalz*) fulphurated or oily falt of phofphorus (which Leonhardi looks upon to be only impure phofphorus). This being feparated, the aromatic fmelling fluid on diftillation gave at firft a fluid that fmelled very pleafant, but lefs cooling and more fuffocating, and which tafted very differently from vitriolic ether; it mixed difficultly with water; and then appeared a fluid, lefs pleafant to the tafte and fmell, which united more eafily with water, and feemed to approach to the firft, as Hoffmann's anodyne fpirit does to vitriolic ether.

Although Margraaf, Rouelle, the duke de Chaulnes, and other chemifts have directed the purification of the phof-

phoric acid by ſpirit of wine, yet, according to Ker, there is reaſon to believe that a portion of it is ſoluble in this ſpirit; for Lavoiſier obſerved, that not only heat was excited on mixing theſe two fluids, but when they were diſtilled, the acid was volatilized, as the liquor which paſſed was ſtrongly acid, of a pungent, unpleaſant, arſenical ſmell, inflammable with ſmoke and miſcible with water in all proportions; it precipitated ſilver and mercury, but not gold from their ſolutions, and although not an ether, it appeared an approximation to it.

Opinion of Morveau.

Prieſtley, who had obſerved, that this acid ſaturated with red nitrous vapours became of a deep indigo colour, has announced another property of it, ſtill more curious. Having digeſted it upon ſome minium from which he had expelled all the air by heat, and which was conſequently in the ſame ſtate as when it affords vital air by the nitrous acid, he obtained by means of heat a great quantity of elaſtic fluid, that came over in a very turbid ſtate; ſcarcely precipitated any lime water, but was very inflammable, burning with a brilliant white flame, and had the odour of phoſphorus; the minium was changed from yellow to a deep gray, and almoſt black colour. Morveau, on adding this fact to thoſe of the revivification of gold in aqua regia, and the ſlow decoloration of a phoſphoric ſolution of mangaueſe, is inclined to believe, that the phoſphoric acid retains, even after having loſt it's ſtate of ſulphur, a portion of phlogiſton, which it is able to yield under certain circumſtances, and which at leaſt gives it the faculty of acting like the phlogiſticated acid; but on conſidering all theſe phenomena, it is neceſſary to be guarded againſt the phoſphorus which almoſt always remains undecompoſed in the acid. If alcohol aſſiſts in volatilizing it, this chemiſt has proved, that it contributes at the ſame time to reproduce, even by the moiſt way, a new portion of phoſphorus; hence, in ſuch

delicate experiments, an acid ought only to be truſted that has been evaporated, puſhed nearly to a vitreous ſtate, and then abandoned to deliqueſcence. To diminiſh the loſs of the acid taken away along with the water, a retort, or at leaſt a matraſs with a long neck ſhould be made uſe of.

It's affinities.

Affinities of the phoſphoric acid. According to Bergman, the affinities of the phoſphoric acid are in the following order:

Lime.	Zinc.	Biſmuth.	Spirit of wine.
Barytes.	Iron.	Antimony.	Phlogiſton.
Magneſia.	Manganeſe.	Arſenic.	He places in the
Potaſh.	Cobalt.	Mercury.	ſame order the
Soda.	Nickel.	Silver.	earths and alka-
Ammonia.	Lead.	Gold.	lis, reſpecting
Alumine.	Tin.	Platina.	their affinities in
	Copper.	Water.	the dry way.

Phlogiſton.

Wenzel looks upon this acid to have a greater affinity to phlogiſton than alkalis, becauſe by the aid of heat it is ſeparated from alkalis in the ſtate of phoſphorus, and becauſe phoſphorus is neither attacked nor decompoſed by alkalis. But, according to Morveau, it is neceſſary to recollect, 1ſt. that it is only the ammoniacal phoſphat that paſſes to the ſtate of phoſphorus, and that parts with it's volatile baſis by the action of heat alone, without the intervention of a third ſubſtance producing this decompoſition by it's affinity; 2. that phoſphorus is not the acid, and even does not contain it entire; hence it's affinities are different. According to Bergman, this acid comes after the vitriolic and dephlogiſticated muriatic acids in the order of affinities with reſpect to phlogiſton; it is however certain, according to Morveau, that phoſphorus is not decompoſed by either of theſe acids. With reſpect to the firſt, Morveau obſerves, that phoſphorus melts in it by the aſſiſtance of heat, that it then riſes to the ſur-

face, and that the portion in contact with the air gives some tokens of combustion, but the rest undergoes no change, and Lassone and Cornette appear to have observed the same. With respect to the second, phosphorus was preserved without any change in dephlogisticated muriatic acid gas obtained in a concrete form according to Berthollet's method, *i. e.* in the highest degree of concentration and power. It is unnecessary to inform the reader, that with respect to the affinity of this acid with phlogiston, as the last principle is now looked upon as merely imaginary, the opinions are erroneous.

Bergman has very properly placed lime as superior in affinity to alkalis, although the authors of the Elements of Chemistry, published at Dijon, assert the contrary, viz. that alkalis have a stronger affinity to this acid than earths. According to Morveau, if a caustic alkaline solution be poured into a solution of calcareous earth by the phosphoric acid, an abundant precipitate is immemediately formed; in consequence of which, it may be supposed, that the alkali has a greater affinity with this acid than the lime; and it was this appearance that deceived Lavoisier on the order of these affinities, and Wenzel, on the existence of a peculiar earth in ivory; but as Bergman observes, the calcareous earth can be only held in solution in this instance by the excess of acid, and on taking away this excess of acid by an alkali, the insoluble earthy salt is precipitated; hence it is not a simple earth, but real calcareous phosphat that forms the precipitate. Let some lime water be poured into a solution of phosphat of potash, and a precipitate is immediately formed, which is the phosphat of lime; and if the quantity of lime water be sufficient the whole acid will be thus precipitated, and the alkali alone will be left in the liquor; this leaves no doubt of the superior attraction of the earthy basis. The case is different if a mild alkali is used; the phosphat of Lime.

lime is then decompofed by double affinity, and it is the lime united to the fixed air that is precipitated. According to Morveau, it was by fuch means that the Academicians of Dijon decompofed the offeous earth, on treating it in the dry way with an alkali that contained the mephite of potafh.

This acid gives up it's earthy bafes to the vitriolic, nitrous, and muriatic acids. According to Ker, the fuperiority of the affinities of ponderous earth and magnefia is, however, not well determined; neither has the affinity of thefe earths compared with that of alkalis in the dry way.

Quartz. This acid, in the humid way, when pure, has no action upon quartz. The property it has of being reduced to a glafs of itfelf would feem to announce, that by the dry way, it ought to be a very powerful folvent of all the earths; but experience does not coincide with this apparent analogy. Morveau in 1779 tried it's fufing nature in the public courfe of the Dijon Academy; the acid obtained from phofphorus by flow combuftion, or as it is improperly called by deliquefcence, was reduced by evaporation to a dry and almoft folid confiftence, it was mixed in this ftate with an equal weight of pure vitrifiable fand, expofed in a crucible for two hours to the moft violent heat of Macquer's furnace, yet the mixture was not vitrified, only a white, porous opake mafs was found, and fo refractory, that part of the crucible, which had been melted upon it into a glafs from the violent heat, was not able even by contact to determine it's fufion. This obfervation agrees with that of Bergman, on the little degree of action of the native phofphat of urine, employed as a flux for quartz expofed before the blowpipe.

Since phofphoric acid has fo little affinity to quartz, it is, according to Morveau, perhaps only by it's action upon other earths or fufing faline bodies, that it attacks

glaſs. According to Ingenhouſz, when it is hot it diſſolves glaſs exactly like the fluor acid, but it is not certain whether his phoſphoric acid was pure, and particularly, exempt from the mixture of undecompoſed phoſphorus. The experiments of Prieſtley are more detailed: this philoſopher employed an acid obtained from phoſphorus by deliqueſcence: he put ſome of this to the height of one inch, into a glaſs tube 30 inches long, and one third of an inch in diameter, hermetically ſealed; in this he kept the acid boiling ſeveral hours, without any evident alteration; he only obſerved, during the ebullition, a white vapour, which aroſe from 15 to 18 inches above the ſurface of the acid. He had hitherto kept the tube in a vertical poſition, but wiſhing to turn it, to let the liquor paſs to the other end, and having applied the flame of a candle to ſome part of the tube that had been moiſtened with the acid, the glaſs was inſtantly covered with a white incruſtation; and having repeated this proceſs at each extremity of the tube alternately, the whole ſoon became ſolid, and the only remaining humidity in the tube was that adhering to it's ſides, which it was impoſſible to make run. A curious circumſtance in this experiment was, that when the tube was very hot, pencils of light were ſometimes ſeen in the interior, extending the whole length of the tube; and then one part of the tube always acquired a ſlight ſtratum of orange coloured matter, equal to that which remains on the glaſs in which phoſphorus has been burnt in the open air. Theſe phenomena afford Morveau no doubt but that the acid employed partook of the properties of phlogiſticated phoſphoric acid, whether by containing ſome undecompoſed phoſphorus, or by reproducing it from the contact of ſome phlogiſtic ſubſtance being accidentally preſent in the tube, or on the ſurface of the glaſs. Hence this chemiſt obſerves, it is not extraordinary that the glaſs was in ſome meaſure

attacked and covered with incruftations; but it is difficult to explain what Prieftley adds, viz. that the white matter found in the tubes after this operation did not attract humidity from the air, and that after being washed it did not preserve any fenfible humidity; for it is well known, that falts formed of phlogifticated phofphoric acid are deliquefcent, and it is difficult to conceive, how the water which renders the acid liquid, remains, as Prieftley fuppofes, in the compofition of the earthy falt formed at the expenfe of the vitreous matter, without rendering it more foluble. Morveau, not fatisfied with the experiments of former chemifts, wifhed to know from his own experience, to what degree the concrete phofphoric acid acted upon glafs; for this purpofe, he took a fmall but very thick phial of green glafs (white glafs, from the manganefe it contains, was liable to error, and being charged with phlogifton, is colourlefs). This phial was filled with phofphoric acid extracted from bones, reduced to a ftate of tranfparent deliquefcent glafs, and afterward pulverized, *i. e.* the pureft that can be obtained in that way, the orifice covered with a fmall piece of well baked pottery, and placed in a crucible filled with quartz fand. After being expofed to the fufing heat of a furnace for one hour, he found the phial depreffed in two places, as to the reft, but little deformed; it was however nothing but a vitreous, folid, and homogeneous mafs, of a very light green, inclining in the middle to an opal whitenefs; it had no longer any favour or folubility; thus the two glaffes were perfectly mixed. At the beginning a few vapours had pierced through the fand, as was expected, and had flightly agglutinated it. This chemift, however, confeffes, that this experiment cannot be looked upon as abfolutely decifive with refpect to the pure phofphoric glafs; as it is certain, that it contained a

quantity of ouretic glaſs, which might have an evident influence on the reſult.

The conſiderable ebullition of aluminous earth with native phoſphat in the eſſays by the blowpipe announces, according to Morveau, a ſufficiently marked affinity; hence, he has obſerved, that Heſſian crucibles, in which the pureſt phoſphoric acid was puſhed to vitrification, were covered with a vitreous coat. He does not, however, think, that the inſolubility of the maſs, which he looks upon as the phoſphoric radical, can be attributed to the formation of an aluminous ſalt. If this was the caſe, the crucibles would be eaſily perforated, and they would be at leaſt evidently affected throughout: inſtead of which, the vitreous coat is only ſuperficial; and what is worthy of attention, it is of a beautiful tranſparency, whilſt it is at the centre of the phoſphoric glaſs, and far from the ſides of the crucibles; and ſometimes a whiter and more opake matter is perceived, which is of equal inſolubility. Clay.

The phoſphoric acid gives up alkalis to the vitriolic, nitrous, and muriatic acids, even to the acetous in the moiſt way, but in the dry, it decompoſes vitriols, nitrats, and alkaline muriats. It has been thought to have a ſtronger affinity to alkalis than theſe acids, becauſe when a mixture of phoſphoric acid and nitre, marine ſalt, or vitriolated tartar is expoſed to a ſtrong heat, theſe ſalts are decompoſed, and their baſes are found to have united with the phoſphoric acid; but this effect does not happen in the *humid way*, and is merely the conſequence of the greater *fixity* of the latter acid, by which means the other acids yield to the force of the fire and are evaporated. Alkalis.

It precipitates ſilver from it's nitrous ſolution, and mercury from it's nitrous and vitriolic ſolutions. Metals.

2. *Phoſphorous acid.* Some years ago this acid was confounded with the phoſphoric; chemiſts had no idea Phoſphorous acid.

that combuſtible bodies might be united with different proportions of oxygen, and that phoſphorus by burning ſlowly formed another acid from what it did when a rapid combuſtion took place with deflagration. It was Lavoiſier who made it known in 1777, that the acid obtained by a complete combuſtion of phoſphorus formed very different combinations from what it did when the combuſtion was ſlow. In 1786, when Morveau publiſhed the chemical part of the Encyclop. Mèthod. this acid is diſtinguiſhed from the phoſphoric by the name of *acide phoſphorique phlogiſtiqué*; and he begins by obſerving, that as the nitrous acid, on loading itſelf with nitrous gas, becomes phlogiſticated nitrous acid, ſo ought the phoſphoric acid, that contains a certain quantity of undecompoſed phoſphorus, to be called phlogiſticated phoſphoric acid; the principles and properties of theſe, as well as of the phlogiſticated vitriolic acid, being entirely analogous, and each the ſolution of a ſulphur by it's own acid. Sage gives this acid the name of *volatile fuming* phoſphoric acid; and Prouſt obſerves there is always a portion of this volatile phoſphoric acid, in the diſtillation of phoſphorus, which is to the phoſphoric what the ſulphureous acid is to the vitriolic. The beſt account of this acid is given by Fourcroy in his *Syſtéme des Connaiſſances chimiques.* It is weaker and not ſo powerful as the phoſphoric acid; contains leſs oxygen; and is the product of a combuſtion, long and only luminous, by which the phoſphorus abſorbs a ſmaller quantity of the acidifying principle, than when the combuſtion is rapid and violent.

How procured. As the phoſphorous acid is never found in it's natural ſtate, it is prepared artificially by collecting it in a proper apparatus from the ſlow and only luminous combuſtion of phoſphorus expoſed to the air of the atmoſphere. If phoſphorus be left expoſed to the atmoſphere, ſo that the air is continually renewed, it begins by it's ſolution in the

azot gas, it then combines by degrees with the oxygen, and it's acid is conveyed into the atmosphere in the state of gas, whilst it's successive formation is accompanied by flashes of light easily observable in the dark. If, however, this process be performed in a close apparatus, without the air being able to circulate around the phosphorus, and into which the atmospheric air is only permitted in a quantity sufficient to keep up the luminous combustion, the acid formed envelopes the phosphorus with a vapour, white during the day, but luminous at night: this condenses on the surface of the phosphorus, and attracting the humidity of the air, dissolves and falls in the form of drops. These drops are the phosphorous acid, but the proportion of the principles, phosphorus and oxygen, cannot be ascertained on account of the water, which combining with the acid, liquifies it.

The method of procuring it, therefore, is to have an apparatus that will admit the air by degrees, and receive the acid as it becomes liquid. For this purpose, rolls of phosphorus are put into glass tubes, open above, and drawn to a point below, where they are also open; these tubes are placed in a large funnel, so that their extreme points may be directed towards it's stem, which is received in a decanter. By such means, the pieces of phosphorus being isolated, are not heated by contact, and are not subject to be exposed to inflammation by a rapid combustion, which often happens when placed naked by each other in the funnel. The funnel and decanter, placed on a plate, is then covered by a glass bell, having two small lateral holes with stoppers, that are taken out or not, according as it is necessary to increase or diminish the combustion. The bottom of the bell reposes upon water, with which the plate is covered, and which, at the same time, affords the acid a proper menstruum. The liquid phosphorous acid runs by degrees into the decanter, and about

three times the quantity of the phosphorus is obtained of it, which, before it's difference from the phosphoric acid was known, went by the name of *phosphoric acid by deliquescence*. The phenomena accompanying the formation of this acid, the weak light, and insensible heat, so different from the burning ardour and lively flame observed during the preparation of the phosphoric acid, prove, according to Fourcroy, that this acid not only differs from this last, by a smaller proportion of oxygen, but also by the state of this acidifying principle, appearing to be much less solid, and retaining more heat than the phosphoric, and these two differences explain those of it's properties.

It's properties.

The phosphorous acid thus prepared, according to the process of Pelletier, is in the form of a white liquid, of the consistence of a sirup somewhat ropy, forming striæ on the glass like an oil; this consistence, however, varies according to the state of the air during it's formation. It is more liquid when the air is very humid; it's specific gravity appears to be somewhat less than that of the phosphoric; it's sour, sharp savour, which sets the teeth on edge, is not very different from that of the phosphoric, and the taste is not able to distinguish them, the excess of the phosphorus in this not being evident. It also reddens the blues of vegetables in much the same manner. It is not changed by light, which it refracts more strongly than the phosphoric, from it's density. With heat it is very different, and, according to Fourcroy, it is by it's action it is to be particularly distinguished from the other. When the phosphorous acid is exposed in a glass retort, it first loses a part of it's water; when concentrated, blebs suddenly arise from the bottom of the vessel, and burst at the surface of the liquid, into a thick, white smoke, sometimes inflaming, when a sufficient quantity of air is in the apparatus. If this experiment be

Differs from the phosphoric.

made in an open veſſel, each bleb expoſes to the air a vivid deflagration, and expands an infectious odour, as if ariſing from phoſphorated hydrogenous gas. Theſe inflammable blebs continue a long time, and the phoſphorous acid is not without great difficulty deprived of the matter, *i. e.* of the phoſphorus that forms them by it's diſengagement, and thus brought to the ſtate of very pure phoſphoric acid. This, however, after a long operation, is at laſt effected, and the remaining acid preſents all the properties of the phoſphoric already related. In making this experiment, it ought not to be forgotten, that the phoſphorous gas only flies off when the phoſphorous acid isvery concentrated and hot, a proof, according to Fourcroy, that phoſphorus not ſaturated with oxygen adheres to it very ſtrongly.

There is very little affinity between oxygen and the phoſphorous acid, although the laſt is not ſaturated with it, ariſing, as Fourcroy affirms, from the great adherence of phoſphorus in phoſphoric acid. To produce it, it is in vain to expoſe the phoſphoroas acid to oxygenous gas, it is only with extreme ſlowneſs it abſorbs a ſmall quantity. Indeed, it cannot be converted into the phoſphoric acid by thoſe means, and it ſucceeds only by a long ebullition; even the glaſs made of phoſphorous acid appears ſtill to retain a portion of phoſphorus, as it differs from that made of phoſphoric acid, by exhaling often a fetid garlic ſmell, and emitting ſparks of light on being rubbed in the dark, which pure phoſphoric glaſs will not. It is the ſame with the phoſphorous acid expoſed to the air; is very difficultly forms phoſphoric acid, in ſpite of the tendency of the azot gas to diſſolve the phoſphorus by releaſing it's bond with the phoſphoric acid. It may be expoſed many months to the air without being converted into phoſphoric acid, but it is ſomewhat ſooner if it be diluted with a quantity of water. This indiſpoſition of the acid to

It's action upon different bodies.

change, makes it differ from ſeveral other acids that may be compared with it on account of their weak acidification, and the ſuperabundance of their radical.

Hydrogen and hydrogen gas have no action upon the phoſphorous acid. It is decompoſed by carbon, red hot, which ſeparates more phoſphorus from it than from the phoſphoric acid, beaauſe it contains more. In the cold there is no change; ſulphur has no action upon it in the cold, nor in the heat; becauſe the exceſs of phoſphorus eſcapes before it can unite to the ſulphur. It has no effect on the diamond. The action of this acid diluted with water, on thoſe metals that decompoſe this laſt fluid more or leſs, differs from that of the phoſphoric, by the hydrogen gas diſengaged. This gas contains a ſmall portion of phoſphorus in ſolution, which renders it very fetid, without, however, it's being inflammable in the air, the quantity not being ſufficiently great. This diſengagement of phoſphorus diſſolved in hydrogen gas, according to Fourcroy, announces the combination that takes place to be only that of the phoſphoric acid being deprived of the ſubſtance that conſtituted it phoſphorous acid.

It is ſoluble in water in all proportions, but on diſengaging this liquid in order to concentrate it, the phoſphorus towards the end of the proceſs leaves the acid, which becomes phoſphoric acid. It cannot therefore be had ſolid, not becauſe of it's adherence to the water, but becauſe it loſes at the ſame time by the heat, the exceſs of phoſphorus from which it derived it's diſtinguiſhing character. This acid unites to moſt of the metallic oxyds with which it forms ſalts nearly inſoluble. Some give up to it, even at a low temperature, a portion of their oxygen, ſo that by approaching to a metallic ſtate, they convert it into phoſphoric acid. This acid is ſtronger than the carbonic, and weaker than the phoſphoric acid; it ſeparates moſt bodies united to the firſt, even water, in the

form of gas, and it gives up to the second almost all it is united with.

Phosphites. The phosphorous acid, with alkalis and earths, forms salts that are called *phosphites*, of which the generic characters are, to emit a phosphorescent flame on being heated; to give a little phosphorus when exposed to a great heat, and thus repass to the state of phosphat, but in less quantity than before. The phosphite of potash has a saline acute savour, very little luminous before the blowpipe, very little deliquescent, very soluble, and more so by heat, and is precipitated by the solutions of lime, barytes, and strontian; it's form is a prism, with four sides terminated by a diedral summit. Phosphite of soda, is a four-sided prism, with a pyramid of four sides, it effloresces slightly, is somewhat more soluble by heat than in the cold. Phosphite of ammonia, affords before the blowpipe strong phosphoric sparks, and a flame with a white vapoury ring, and furnishes phosphorated hydrogenous gas by distillation. Phosphite ammoniaco-magnesian unites to the weak property of the preceding, that of affording sulphat of magnesia with sulphuric acid. Phosphite of alumin is styptic, of a gummy consistence, and swells in the heat. Phosphite of lime is in the form of powder, very neutral, pungent when acid, not to be decomposed by any basis. Phosphite of barytes is an insipid powder, very luminous before the blowpipe, the acidule is more soluble than that of lime; it's solution is rendered turbid by lime water. Phosphite of magnesia is insipid, in flocks, or very small tetraedral crystals, it effloresces, and is very little soluble. With respect to the proportions of the component parts of the phosphites, they are as follows:

Phosphite of potash	Phosphorous acid	39.5.
	Potash	49.5.
	Water	11.

Phoſphite of ſoda	Phoſphorous acid	16.3.
	Soda	23.7.
	Wafer	60.
of ammonia	Phoſphorous acid	26.
	Ammonia	51.
	Water	23.
of lime	Phoſphorous acid	34.
	Lime	51.
	Water	15.
of barytes	Phoſphorous acid	41.7.
	Barytes	51.3.
	Water	7.
of magneſia	Phoſphorous acid	44.
	Magneſia	20.
	Water	36.

Phoſphites miſtaken for phoſphats.

Chemiſts, without ſuſpecting it, have been employed in the examination of alkaline and earthy phoſphites. For uſing the acid prepared from the ſlow combuſtion of phoſphorus, they imagined they were forming phoſphats, inſtead of which the formation of phoſphites was the effect. Hence Lavoiſier obſerved on the combinations of the phoſphoric acid, from a rapid combuſtion, that if the products of other chemiſts were different from his own, it aroſe from their employing another acid, *i. e.* the phoſphorous. It is to Fourcroy and Vauquelin that we are indebted for a ſyſtematic inveſtigation of theſe ſalts, for before, theſe phoſphites were little or not at all known.

Method of diſtinguiſhing them.

It is neceſſary to recollect, that the phoſphorous acid differs from the phoſphoric, by a leſs quantity of oxygen, or a greater proportion of phoſphorus; that it is formed at a leſs temperature, and by ſlow combuſtion, that it may be looked upon as a ſolution of phoſphorus in the phoſphoric acid; although it cannot be thus prepared, becauſe the heat neceſſary for this ſolution has more affinity to the phoſphorus than this laſt to the phoſphoric acid.

Hence, when liquid phofphorous acid is heated fome time, a luminous thick white vapour arifes in the dark, which is lighted at a certain degree of temperature, and is volatilized phofphorus, which being once feparated from the phofphorous acid, leaves it in a ftate of pure phofphoric acid. Thefe characteriftic properties of phofphorous acid are the real caufes of thofe that ferve to diftinguifh the phofphites.

All phofphites are the production of art; by uniting their bafes with the phofphorous acid, and evaporating and cryftallizing the folutions when capable of it, and wafhing them well, when not. Some are formed by a double attraction, by mixing folutions of phofphites with thofe of nitric and muriatic falts. Although thefe phofphites agree in fome refpects with phofphats, they differ from them in others. Their form, when fufceptible of a regular one, is always more or lefs different from that of phofphats with the fame bafis. Their favour is not the fame, that of phofphites having always fomething fetid, acid and of garlick, not perceptible in phofphats.

Their properties.

All phofphites are fufible, afford, on being heated in clofe veffels, a little phofphorus, thus paffing to the ftate of melted phofphats, and are then unchangeable. Before the blowpipe, all melt into a vitreous, tranfparent, or opake globule, and all emit on fufion, a phofphoric light, often even fparks of flame, accompanied with a ftrong fmell of garlick, and a white thick vapour, not obferved in phofphats. After this vitrification, they are converted into phofphats, lefs in quantity than when phofphites. They undergo no change in the common air, and differ, as to the water they contain, according to the fpecies. Combuftible bodies have no more effect upon them than upon phofphats. Some are very foluble in water; others weakly; and others not at all. Several are more foluble in heat than cold, and cryftallize on cooling. They often

reduce metallic oxyds by contact or by heat, and then become phofphats by taking oxygen from thefe oxyds. They are nearly all decompofed by acids, even by fome that are weaker than the vegetable; which proves this acid to have lefs attraction for the bafes than the phofphoric has. This laft difengages the phofphorus from them. The phofphorous acid renders feveral phofphites more foluble, to whfch it adheres, and which it brings to a ftate of acidulous phofphites. The nitric and oxygenated muriatic acid immediately change phofphites into more abundant phofphats. The bafes have a different attraction for the phofphorous than the phofphoric; hence phofphites follow different laws of compofition from phofphats. Lime and magnefia are here fuperior to fixed alkalis in attraction, and barytes yield it to lime. They in general decompofe other faline earths, except thofe with the fame bafis. Nitrats and furoxygenated muriats, with which they detonate by heat, change them into phofphats. Suroxygenated muriat of potafh inflames and detonates with them by fimple percuffion, from the excefs of phofphorus they contain. They often reduce to a metallic ftate, more or lefs fo, oxyds diffolved in acids. Such are the general characters of phofphites as defcribed by Fourcroy.

The phofphorous acid attacks glafs in the humid way, but it's action is flow and very weak, and by no means to be compared to the action of the fluoric; it however acts more powerfully than the phofphoric acid.

Encycloped. Méthod. art. Acide Phofphorique, tom. 1. part 1. p. 202. Chimie.—Firft part of a Dictionary of Chemiftry by J. Ker, art. Phofphoric Acid.—Philofophie Chimique, p. 6, 63.—The moft advantageous method of obtaining phofphoric acid, by Mr. Sueron, Apothecary of Kiel, in the Nordifch. Archives, No. 2.—Boyle's Philo-

ſoph. works, by P. Shaw, M. D. 3 vols. art. Artificial Phoſphori, London, 1723.—Margraaf's Chemiſch. Schriften, Berlin, 1768. p. 51, 84. 1 Keil.—Macquer's Chem. Wœrterb. 3 K. art. Phoſphorſaure.—Account of a Memoir of Mr. Prouſt, on ſeveral intereſting Points of Chemiſtry, Nicholſon's Journal, No. 45, p. 355.—Crell's Neueſt. Entdec. t. v. ſ. 135.—Journal de Phyſ. par Roſier. t. 26. p. 187, t. 28. p. 30—De Laſſone and Corvette, and in Crell's Chem. Annal. 1786. 2. p. 463, Ueberſetzt von Mém. de l'Acad. des Sciences à Paris, 1780 —Wenzel von der Verwandtſhaſt, ſ. 220.—Crell's Chem. Journ. t. 4. ſ. 93.—Sur le Carbone retiré du Phoſphore, Extrait d'une Lettre de M. von Crell, au Citn. van Mons. an de ch. t. 23. p. 325. 1797.—Extrait par le Citn. van Mons. ſur la Cryſtallization de l'Acide Phoſphorique, ibid. p. 74.—Syſtéme des Connoiſſances Chimiques, &c. par A. F. Fourcroy. t. 2. p. 43. t. 3. p. 230.

SEBACIC ACID.

It appeared on treating of fat, that by the dry diſtillation of this animal ſubſtance, beſides an empyreumatic, partly fluid, partly coagulated oil, an inflammable acid liquor was obtained, from which, by repeated diſtillation, an acid may be procured, known by the name of the ſebacic acid, or acid of fat. Sebacic acid.

According to Fourcroy's definition of it, it is an acid extracted from fat by the action of the fire, likewiſe ſeparated from it by alkalis and lime, with the aſſiſtance of a ſtrong heat; it is a white, fuming liquid, of a very acid taſte and ſmell, forming cryſtallizable and fixed ſalts, with earth and alkalis, decompoſing the muriat of mercury, and is decompoſed by a ſtrong heat. Fourcroy's definition of it.

It had long been ſuſpected, from the ſharp and ſenſible

impreffion which the fmoke of the fat of animals made on the organs of fmell, that it contained a concealed acid. We are informed by Morveau, that Olaus Borrichius, in the Tranfactions of Copenhagen (Collect. acad. part. etrang. tom. vii. p. 374) has given a ftriking obfervation of the danger of the exhalations which arife from melting fat, which penetrate the noftrils, the eyes, and even the lungs. The effects, however, of thefe exhalations, were nearly all the proofs of an acid exifting in that fubftance. They were likewife produced from the diftillation of vegetable oils, and fome animal matters analogous to them, and by the action of acids in the coagulation of fluid oils. It was principally on this laft phenomenon, that Cartheufar, in his Elements of the Materia Medica, printed at Frankfort, in 1740, founded his opinion of the exiftence of an acid in fats.

Borrichius.

Cartheufar.

Thefe opinions, however, were but little better than conjecture; and the firft perfon who proved by experiments, that animal fats really gave out an acid, was, according to Leonhardi, Francis Gruetzmacher, who publifhed a differtation on this fubject, at Leipfig, in 1748. In 1753, a more exact analyfis of fat, and a more convincing proof of the exiftence of this acid in fat, was publifhed by Rhades, at Gottingen, in a little work entitled, Differ. de Ferro Sang. Hum. Aliifq. Liqu. Animal.

Gruetzmacher firft proved the exiftence of an acid in fats.

Rhades.

In 1754, Segner and Knape publifhed a differtation on this acid, which contains fome well-made and ingenious experiments on the fubject.

Segner and Knape.

The experiments, however, of thefe chemifts did not prevent d'Aumont, when the firft edition of the Encyclopædia came out, from maintaining againft Cartheufar, that this acid had no exiftence, and that there was no fuch a fluid to be obtained in the analyfis of fats. His article was afterwards corrected in the fupplements of the

It's exiftence oppofed by d'Aumont.

great Haller, who pofitively afferted, that the human fat and marrow afforded, by means of heat, a volatile empyreumatic and acid liquor, which effervefced with alkalis, reddened the firup of violets, and produced cryftals by it's union with volatile alkali. Haller afferts it's prefence.

Macquer, in his chemical dictionary, had only juft mentioned this acid; and it is to Leonhardi that chemifts are indebted for the addition of the article Fettfaure in his German tranflation of that excellent work. Macquer.

For the moft complete differtation on this fubject, we are obliged to Crell, who has endeavoured, by a number of well-directed experiments, to perfect the procefs for the feparation and rectification of this acid, and to determine the properties of it's combinations with other fubftances. It is from the memoirs of this celebrated chemift, fome experiments, repeated by Maret in the public lectures of the Academy of Dijon, and what the illuftrious Bergman has faid of it in his treatife on elective attractions, that Morveau has digefted the article *febacic acid*, in the Encyclopédie Méthodique. Crell.

OF THE PREPARATION AND RECTIFICATION OF THE SEBACIC ACID.

Crell, in order to feparate this acid from it's oil as it is obtained by the diftillation of fat, and at the fame time to procure it in a ftate of concentration fufficient for the examination of it's properties, made a great variety of experiments, the greater part of which, it appears, only ferved to convince him of the difficulty of this operation. His method of obtaining the febacic acid pure.

Having been perfuaded, from his experiments on fat, that the febacic acid was fimply difengaged, and not produced during the diftillation, he conceived the hopes of fixing and uniting it with an alkaline bafis, which, at the fame time, would convert the oily part into a ftate of

ſoap, ſo that nothing further would be neceſſary than to ſeparate the neutral ſalt from the oily parts of the ſoap; and experience juſtified the theory of the proceſs.

" I covered", ſays he, " exactly 8 ounces of recent quicklime, before it's extinction, with one pound of potaſh, and I left theſe two ſubſtances in a glazed earthen veſſel until the lime began to be extinguiſhed. I then poured three pints of water upon them, and reduced it, by means of ebullition, to one quarter, and filtered it. This ley was found to be as ſtrong as that which goes by the name of ſoap-boilers' ley, and ſupported a freſh egg in the ſame manner. I then took one quarter of this ſolution, added a little water to it, and boiled it with one pound of ox ſuet, until all the humidity was nearly evaporated, and the whole well combined together. I then added to it the remaining parts of the ley, and continued to boil the whole, ſtirring it from to time, until the mixture became tranſparent, and, as it were, mucilaginous, and until it became, on cooling, of a gelatinous conſiſtence; it had then all the appearance of common ſoap before common ſalt is added to it."

The next circumſtance, was to decompoſe this ſoap, and by ſuch means to ſeparate the oil from the neutral ſalt that would be formed. To do this, Crell preferred alum as the cheapeſt method; and becauſe he had no fear of it's decompoſing the ſebat of potaſh in the moiſt way.

He diſſolved the ſoap prepared with the fat, in boiling water, and added to it a little alum, ſlightly broken. Scarcely was it in the water when the fixed oil aroſe to the ſurface; this he ſkimmed off, and repeated the proceſs of adding alum, and ſkimming it, until nothing more aroſe to the ſurface. He then filtered the ley, which was of a yellow colour, and had a bitter taſte, in order to ſeparate entirely the precipitated alum, as well as

ſome parts of the fixed fat, which ſtill floated on the top, and he evaporated it to dryneſs.

Having procured by theſe means, the ſebat of potaſh, he endeavoured to diſengage the acid from it by means of alum, in order to be certain of it's paſſing over without being mixed with the vitriolic acid; but he recollected, that the contact of the inflammable matter had favoured the decompoſition of a part of the alum; and he was convinced, from an evident odour of phlogiſticated vitriolic acid, perceptible at the mouth of the veſſel, that the product would not be leſs changed with this foreign acid; he therefore returned to the uſe of the vitriolic acid, as the moſt ſimple method, and which did not require ſo much trouble, or ſo ſtrong a fire.

He repeated theſe operations more at large, to determine exactly the proper quantities, and after many trials, he found, that to ſix pounds of the abovementioned prepared ſoap, of a gelatinous conſiſtence, it was neceſſary to add nearly 22 ounces of alum previouſly diſſolved in water; that after having filtered and evaporated the liquor, nearly 21 ounces of ſalt were obtained, part of which was vitriol of potaſh, part ſebat of potaſh, and a little alum not decompoſed.

To three parts of this ſaline reſiduum, four ounces and a half of common concentrated vitriolic acid are to be added, which give riſe to heat and vapours; the whole is then to be diſtilled by increaſing the fire by degrees, and the produce will be a little more than five ounces of a yellow, fuming liquor, which is the ſebacic acid.

In general, this acid is ſufficiently pure; it is, however, well to be certain of it's not containing any vitriolic acid. For this purpoſe, a little acetite of lead is to be poured on it, and if the precipitate be not perfectly ſoluble in vinegar, it is a proof of the formation of vitriol of lead, and that the ſebacic acid contains a portion of the

vitriolic acid. But the moſt certain method is, to rediſtil the ſebacic acid upon a portion of the ſame ſalt; and it is on this account that Crell recommends the reſerve of one fourth part of it, becauſe it not only leaves behind it all the foreign ſalts which may have come over with it, but alſo it's yellow colour.

The product of this rectification is a clear colourleſs acid, ſtill, however, fuming, and of a very penetrating odour.

According to Morveau, this acid has been for ſeveral years demonſtrated in the public lectures of the academy of Dijon, by Maret; and the proceſſes indicated by Crell, have conſtantly ſucceeded, (vide Nouvelles de la République des Lettres de M. de la Blancherie. Ann. 1782. No. 17.)

Another method of procuring it.

Inſtead of reducing the fat to a ſtate of ſoap by an alkali, it is generally decompoſed by quicklime, in the following manner: The fat is previouſly melted in an iron pan, ſome pulverized quicklime is then added, and at the beginning it is conſtantly kept ſtirring; towards the end of the proceſs a very ſtrong heat is applied, taking care, by raiſing the veſſel, not to be expoſed to the vapours. When the whole is become cool, the fat is found to have undergone a loſs of ſolidity; it is to be boiled in a large quantity of water, the ley filtered, evaporated, and a very acrid, brown ſalt is obtained, which is the *ſebat of lime*. This ſalt is very ſoluble in water; but as it would be too tedious and even difficult to purify it completely by repeated cryſtallizations, it is eaſier effected by expoſing it to a heat capable of roaſting the oil that blackens it, after which it is ſufficiently purified by one ſolution; it leaves it's oil on the filter in a ſtate of coal, and nothing remains but to evaporate it.

As it is better to add more lime than is neceſſary for

saturation, in order to multiply the points of contact, and to render the decomposition of the fat complete, the solution generally contains a little quicklime, and this is easily taken away by the addition of some water impregnated with carbonic acid, which does not decompose the sebat of lime.

This salt, distilled in vitriolic acid, gives up it's sebacic acid in the same manner as the sebat of potash.

Nature and properties of the sebacic acid. This acid, when pure, is a pellucid, colourless fluid; but deprived of it's water, it is in a gaseous form. When, however, it is just extricated from fat, it is united with part of the oil, which gives it a gold yellow, or reddish colour. The action of the fire likewise gives it a yellow colour. Pure sebacic acid. It's properties.

It's aroma is insupportably strong, penetrating and suffocating.

It's savour moderately acid, sharp, and burning.

It reddens the tincture of litmus, but scarcely the sirup of violets, and it effervesces with alkalis and earths in their mild state. United with potash to the point of saturation, it forms quadrilateral daggershaped crystals, fixed in the air. To the taste, they are sharp, saline, nearly ammoniacal, but milder. This salt does not inflame in the fire, or decrepitate when cast on red hot coals. On distillation, gray vapours arise, which form a gold yellow, but very weak acid, of the smell of spirit of tartar: the residuum is alkaline and mixed with coal. It is decomposed by the vitriolic, nitrous, and muriatic acids; and on distillation with these, it's acid part is forced over. Alum has the same effect. On the contrary, vinegar, fluor and phosphoric acids, and white arsenic, are incapable of decomposing this salt in the dry way, and consequently of liberating it's acid. This salt is the *sebaceum potassinum* of Bergman, or the sebat of potash.

With soda, it forms brownish crystals, which by mo-

derate fusion, solution, and evaporation, although somewhat difficult, yet at last form white spearshaped crystals. This salt deliquesces by a gentle heat, but becomes solid again on cooling; from which, as a middle point, four-cornered crystals arise, ending for the most part in three-cornered, pointed pyramids. In the air, they effloresce and become white. They resemble in taste, terra foliata tartari.

The sebacic acid, saturated with volatile alkali, affords a white ammoniacal salt, capable of sublimation, and resembling common ammoniac in taste, and it's cooling property, but which cannot volatilize iron and bloodstone in the same manner as common ammoniac.

With lime, this acid forms an earthy salt, producing sexangular crystals terminating in a flat surface. The taste is sharp and saline, but not so burning as the muriat of lime. It is easily soluble in water, but insoluble in alcohol; nor does it deliquesce in the air. It is not decomposed by alum.

It does not form a crystallizable salt with magnesia, but unites with it into a gummy bitterish mass, which is very deliquescent in the air, called by Crell, sal amarum animale.

This acid unites to the earth of alum with the greatest difficulty. This earth, precipitated by fixed alkali, and still moist, on being dissolved and exposed to evaporation, formed with it a shapeless salt, that was harsh, and contracted the organs of taste.

This acid, according to Crell, has no action on silex; but Morveau is disposed to believe, that it acts, if not upon pure quartz, at least upon glass. Crell having digested it several times upon gold, always obtained a white, earthy precipitate, which was not calcareous earth; and Morveau thinks, that the acid acts upon glass in a similar way to the fluor acid. This conjecture appears to him

probable, from obferving fince, that the empyreumatic firupy acid attacked and very fenfibly wafted the glafs.

The febacic acid, boiled upon gold leaf, and upon platina, appears to commence a folution, but fo weak that Crell, after many experiments, defires a further examination. When mixed with the nitrous acid, it diffolves gold, even in the cold; it unites, although difficultly, with the calx of gold, and forms a cryftallizable falt; it does the fame with the precipitates of platina. The one affords yellow, the other yellowifh brown cryftals. It precipitates gold from it's folution in aqua regia of a yellow colour, and platina of a yellowifh red. Thefe precipitates, when edulcorated, attract moifture from the air; but that of the platina, which is become grayifh yellow, the leaft.

It diffolves metallic filver in fmall quantity, which is precipitated by muriatic acid, of a white colour, and by copper, in the form of metal. By means of long digeftion, this acid diffolves the calx of filver, and affords fmall, dark coloured cryftals. It precipitates this metal from it's folution in the nitrous acid, of a white colour; it deprives the vitriolic acid of it's filver, but yields it to the muriatic.

By repeated extraction from living mercury, it changes it into a filver coloured mafs, which is not decompofed by common falt, but refigns it to copper in a metallic ftate. It deprives the nitrous folution of mercury of it's metal. The precipitate obtained from corrofive fublimate is in great part diffolved by it in the cold, and the extracted folution, by a moderate heat, affords a real white fublimate, which is extremely difficult to be diffolved in water, even by a digefting heat, and affords a white precipitate with potafh, which is therefore very different from the common corrofive fublimate. With volatile liver of fulphur, this folution affords a black pre-

cipitate, which, in a ſhort time, leaves a cinnabar; it colours copper white, even when rubbed upon it in a dry ſtate. The ſolution of common corroſive ſublimate precipitates the ſebacic acid white, which is a peculiar character of it, and ſhows that this acid prefers mercury before any other. This acid changes the ſurface of copper, even in the cold, to a green colour; but by the aſſiſtance of heat, a ſolution is obtained, which, on evaporation, is inclined to cryſtallize, but deliqueſces again in the air. It neither takes this metal from the vitriolic nor nitrous acid.

With iron, it affords a ſolution of an aſtringent taſte, and needle-ſhaped cryſtals, which deliqueſce in the air. It neither precipitates iron from it's vitriolic nor nitrous ſolution.

It only corrodes lead in it's metallic ſtate, and cauſes a turbidneſs. It diſſolves minium in larger quantity, and changes the inſoluble remainder to a white powder. This ſebacic ſolution of lead has a ſweetiſh taſte, and is not decompoſed by common ſalt. It precipitates lead from it's nitrous ſolution, and forms with it white, needle-ſhaped cryſtals, eaſily ſoluble in water, which being evaporated a pulverized maſs is produced, not very capable of imbibing moiſture, but decompoſable by the vitriolic acid. According to Bergman, it decompoſes the muriat of lead. It precipitates the ſolution of the ſugar of lead, of a white colour, yet this precipitate is again diſſolved by ſtrong vinegar, when it is perfectly free of vitriolic acid.

It corrodes pure tin filings in the cold, but more ſo by heat, to a yellow powder, from which an extremely diſagreeable ſmell ariſes; by repeated filtration, this ſtill remains turbid; but after repoſing ſome time, it depoſits a yellow powder, and receives a beautiful roſe colour. This yellow corroded powder affords, with water, a white

ſalt, which readily deliqueſces in the air. It deprives the reguline acid of it's tin. According to Bergman, this acid likewiſe decompoſes the muriat of tin.

The ſebacic acid has no effect on the regulus of antimony in the cold; but it readily diſſolves it by means of heat, and produces, on evaporation, cryſtals, which are fixed in the air. If this acid be added to a diluted, ſaturated, reguline ſolution of antimony which has been filtered, and becomes no longer turbid by the addition of water, a white precipitate takes place, which, after edulcoration, digeſtion with water, and evaporation of the filtered fluid, affords a whitiſh yellow powder, that becomes moiſt in the air, and produces ſmall cryſtals. According to Bergman, of all the acids, the ſebacic moſt readily unites with the regulus of this metal.

It readily diſſolves zinc, and in great quantity; but does not decompoſe the vitriolic and nitrous ſolutions of this metal.

This acid has no effect on biſmuth in it's metallic ſtate, even by a digeſting heat. It diſſolves, however, it's calx precipitated from nitrous acid, in the cold. This is precipitated by water, in the form of a white powder, although neither the vitriolic nor muriatic acid has any effect. This acid alſo produces from the common ſolution of biſmuth, a white powder, although the ſolution has been made by ſo diluted a nitrous acid as not to be changed by the addition of water. The edulcorated precipitate, digeſted with water, filtered and evaporated, affords a white deliqueſcent reſiduum.

It has no effect on the regulus of cobalt, but readily diſſolves it's calx. This ſolution mixed with ſaltpetre, and evaporated, affords a ſalt, which diſſolved and exſiccated, forms a ſympathetic ink. It does not precipitate cobalt from it's nitrous ſolution.

It does not diffolve nickel in it's metallic ftate, but forms with it's calx a green folution. This is not decompofed by the muriatic and nitrous acids.

It fparingly diffolves white arfenic in the cold, by the means of heat, more abundantly; on becoming cool, fmall cryftals are depofited.

It has no effect on the nitrat of arfenic. It reduces white arfenic by diftillation. It diffolves manganefe in quantity, forming a clear folution, but does not decompofe the nitrous folution of this femimetal.

Mixed with an equal quantity of highly rectified fpirit of wine, it fmoaks without becoming very warm. If this mixture be extracted by a gentle heat after a previous digeftion for fix hours, it gives a liquid, which when added to water produces a milky appearance, and by degrees depofits an oily fluid, aad is a kind of febacic æther or naphtha.

The action of the febacic acid on oils has not been examined.

The affinities according to Bergman.

With refpect to the affinities which the febacic acid has to other fubftances, they are given by Bergman in the following order:

Moift way.		*Dry way.*
Lime.	Lead.	Lime.
Barytes.	Tin.	Barytes.
Magnefia.	Copper.	Magnefia.
Potafh.	Bifmuth.	Potafh.
Soda.	Antimony.	Soda.
Ammonia.	Arfenic.	Calces of Metals.
Argile.	Mercury.	Ammonia.
Calx of Zinc.	Silver.	Argile.
Iron.	Gold and Platina.	
Manganefe.	Water.	
Cobalt.	Alcohol.	
Nickel.	Phlogifton.	

From this ſtate of affinities it ſeems, Bergman has placed the earths before the alkalis; yet he appears to be doubtful of the alkalis yielding this acid to the earths, and on peruſing his diſſertation, he ſeems more willing to believe that the contrary ought to take place. This celebrated chemiſt, however, has not ſaid upon what ground he formed this conjecture; but Morveau has ſeen it confirmed with reſpect to the cauſtic potaſh, which very certainly decompoſes the ſebat of lime. Morveau, therefore, has preſented a table of affinities of this acid, in the Encyclop. Méthod. for the *moiſt way*, in the following order, acquainting his reader that the place of the barytes is not yet well determined.

According to Morveau.

Barytes.	Alum.
Potaſh.	Metallic calces.
Soda.	Water.
Lime.	Alcohol.
Magneſia.	Phlogiſton.
Ammonia.	

In the *dry way*, the metallic ſubſtances go before ammonia and alum. It attracts alum ſo weakly, that if a ſolution of alum be poured into a ſolution of ſebat of lime, no precipitation takes place.

Diſtilled upon alkaline vitriols, it diſengages a little ſulphureous vitriolic acid; this decompoſition takes place, according to Morveau, by means of the phlogiſton, which the moſt pure ſebacic acid always contains.

It is not aſtoniſhing that it precipitates the acidulous tartrite of potaſh, when poured into a ſolution of tartar of potaſh, and alſo the nitrat of potaſh, although the nitrous acid deprives it of the alkali, in the moiſt way, becauſe, according to Morveau, in the dry way, the nitrous acid becomes weak by phlogiſton. With reſpect to the muriatic acid, when diſtilled with the ſebat of potaſh, the acid which comes over, Crell ſays, precipitates the cor-

rosive muriat of mercury, of a white colour, which is the characteristic of the sebacic acid; hence Bergman, who had under his eyes the work of Crell, has put the muriatic acid before the sebacic, in the order of the affinities of alkalis, whether in the moist or dry way.

THE SEBACIC COMPARED WITH OTHER ACIDS.

Sebacic acid compared with other acids.

It is now pretty well ascertained, that this acid exists ready formed in fat, and in considerable quantity, since, according to Crell, two pounds of suet afforded him seven ounces two scruples of this acid. It likewise appears from the before-mentioned experiments, that this acid was directly separated from fat by means of alkalis and earths, even in the humid way, at least by a heat too weak to be regarded as the product of the fire; which facts are so very conclusive, as to appear to Morveau to need no other proof.

It attracts these substances, and forms new salts with their bases, which Morveau calls *sebats*, according to the principles of the new French Chemical Nomenclature. By means of heat, it is resolved into a gas; it is therefore, according to the last mentioned chemist, composed of vital air, the acidifying principle, and an acidifiable basis, like all other acids.

The action of the fire likewise gives it a yellow colour, and it leaves a residuum that announces a partial decomposition, on which account, Crell regards it as holding the medium between the mineral acids that resist a distilling heat, and the vegetable acids that are decomposed by it.

With the muriatic acid.

According to this chemist, it has some of the properties of the *muriatic acid*; thus it forms, with potash, a salt capable of melting in the fire without being decom-

pofed; it acts powerfully upon gold when mixed with the nitrous acid; it precipitates the nitrous folution of filver; it forms a fublimate with mercury, which folution is not rendered turbid by common falt; and pure water feparates antimony from it. It, however, differs from it in the moft clear and evident manner by precipitating a folution of corrofive fublimate, which no other acid is capable of performing; and by it's ammoniacal falt, when mixed and fublimed with falt of iron, not forming flowers containing this metal.

This acid has likewife been compared to *vinegar*, for, according to Bergman, earthy and alkaline febats have a very great analogy with thofe falts that are formed by the union of the acetous acid with the fame bafes; but it is very certain, that the febats of potafh and of foda cryftallize in prifms or in needles, and are much more fixed in the fire and air. Vinegar.

Gren formed a conjecture, that it was the acid of fugar, which he looked upon as confirmed by an experiment of Riecken, who, by extracting moderately ftrong nitrous acid from ox fuet, obtained a very pure acid of fugar. Previous to this experiment, Scheele, having boiled fome animal fat with about half it's quantity of litharge, and a fufficient quantity of water, procured a fweet fubftance from the decanted liquor, which evaporated to the confiftence of a firup; and having repeatedly extracted nitrous acid from it, afforded him the acid of fugar. The difference, however, between the faccharine and febacic acids, is now very well afcertained. Oxalic acid.

Metherie looks upon it as a peculiar acid exifting in fat along with the faccharine matter, whilft it appears very probable to Leonhardi, that it is a peculiar modification of the common vegetable acid, differing in it's Other opinions.

quantity of phlogiſton, and holding the middle place between the ſaccharine acid and vinegar.

The analogy of this acid with the empyreumatic *oily acids* of ſome vegetables is according to the opinion of Morveau much better eſtabliſhed, than with thoſe already mentioned. Crell has extracted one by diſtillation of the butter of the cocoa, and having rectified and tried it's combinations, he found it precipitated the ſolution of ſilver; formed a cryſtallizable ſalt with lime, which did not deliqueſce; and with the volatile alkali produced a real concrete ammoniacal ſebat, very different from that which vinegar affords, &c.; from which he thinks that it was the ſebacic acid. Having likewiſe found it in ſpermaceti and in human fat, and that of fiſh, and quadrupeds, he concludes, that this acid originates from the organized bodies of both the animal and vegetable world, and is an acid *ſui generis*.

Experiments of Thenard.

The laſt chemiſt who has extended our knowledge on the ſebacic acid is Thenard. The principal object of the experiments of former chemiſts was to prove that the product of the diſtillation of fat contains a peculiar acid of extreme volatility, and of ſuch a poignant and ſuffocating nature, that it cannot be reſpired without ſome degree of danger. Thoſe which Thenard gives an account of prove, 1ſt. That this product actually contains a peculiar acid, which however ſo far from being volatile, odorous and ſuffocating, is, on the contrary, ſolid and inodorous. 2d. That it contains acetous acid. 3d. That this new acid has no part in the ſmell of diſtilled fat. 4th. That by all the proceſſes hitherto employed to extract the ſebacic acid, nothing is obtained but a foreign acid, and that conſequently the ſebacic acid has not yet been known.

Methods of obtaining the ſebacic acid.

Having diſtilled a conſiderable quantity of the fat of pork, Thenard, in order to obtain the ſebacic acid, treated

the product at feveral times with hot water, and poured acetite of lead into the liquor; a flaky precipitate was formed, which being collected and dried, was put with fulphuric acid into a retort and heated. The liquid of the receiver had no character of acidity, but in the retort a melted fubftance floated at the top, analogous to fat, which being carefully feparated and wafhed well, was boiled with water. By heat the water totally diffolved it, and by refrigeration cryftalline needles were depofited, of little confiftence; thefe needles were acid and had peculiar properties. To be certain they were not the product of the fulphuric acid, diftilled fat was treated with water, and the liquor being filtrated and evaporated, needles were obtained having precifely the fame properties. To procure this acid, likewife, the diftilled fat being treated with water, the filtrated liquor may be faturated wlth potafh, evaporated, and poured into a folution of lead. A precipitate is here formed which is a febat of lead, that is to be treated as above with fulphuric acid. Such are the three methods Thenard employed to obtain the febaçic acid: according to this chemift it's properties are as follow:

It is without fmell, it's tafte flightly acid, it melts like a kind of fat, confiderably reddens tincture of turnfol, and is more foluble in a hot than cold temperature. Boiling water, faturated with the febacic acid, becomes folid by refrigeration; alcohol diffolves a large quantity of it; it cryftallizes in fmall needles; with care it may be obtained in the form of long, large and beautiful brilliant lamellæ; it precipitates the acetite ahd the nitrat of lead, the nitrat of filver, the acetite and nitrat of mercury; it faturates the caufticity of the alkalis, forming with them foluble falts; with potafh it forms a falt that does not deliquefce, which has but little tafte, and which, if fulphuric, nitric or muriatic acid be poured upon it, becomes It's properties.

turbid and depofits fcbacic acid; when it's folution is concentrated and mixed with one of thefe acids it becomes folid; finally, it does not render turbid the water of lime, barytes and ftrontites. Thefe properties diftinguifh it from all the other acids, and prove it to be an acid *fui generis.*

To feparate the acetous acid from the product after diftillation of fat.

To feparate the acetous acid from the product after diftillation of fat, this product of the diftilled fat is treated with water, the liquor faturated with potafh and evaporated. When the fubftance is dry, Thenard introduced it into a retort with dilute fulphuric acid, or phofphoric acid, and diftilled it, and an acid was obtained having all the characters of acetous acid; with potafh it forms a foliated falt. This falt melts in the heat, and when expofed to the air, deliquefces fpeedily and completely, it's tafte is extremely pungent; with a folution of nitrat of mercury, it forms a precipitate cryftallized in the form of fpangles. When fulphuric acid is poured upon it, acetous acid is difengaged in abundance. Sometimes the water with which the product of the diftilled fat has been treated, contains fcarcely any thing except acetous acid, fo that to obtain acetite of potafh, nothing more is neceffary than to evaporate the liquid. The quantity of febacic and of acetous acid formed in the diftillation of fat, varies in proportion to the greater or lefs degree of heat.

The odorous matter of diftilled fat examined.

In order to examine the odorous matter arifing from the diftillation of fat, Thenard introduced fome fat, which had juft been diftilled, and the fmell of which was extremely pungent, into a tubulated retort. He adapted to the neck of the retort a receiver which contained tincture of turnfol. Having diftilled it with a gentle heat, the receiver became thereby filled with a ftrong odour, and yet the colour of the tincture was not changed, a convincing proof, he thinks, that the fmell of diftilled fat

is not owing to an acid; besides, if this smell depended upon an acid, he thinks, it would probably disappear upon placing it in contact with the alkalis, as the acid would then be absorbed, which is not the case. He therefore concludes, that it depends upon a portion of the fat, converted into gas, and undoubtedly changed in it's nature.

Processes hitherto employed for obtaining the sebacic acid examined.

In examining the different processes which former chemists employed to obtain the sebacic acid, Thenard begins with Crell, who in order to separate the sebacic acid from the product of distilled fat, first added to it a certain quantity of potash, after which he filtrated and evaporated it. As the salt he got was mixed with oil, he calcined it, redissolved it in water and evaporated the solution. By this means he obtained a salt of considerable whiteness and of a foliated texture, which being put into a retort with sulphuric acid and distilled, afforded a pungent and fuming acid. This process however appearing inconvenient, he employed another; for being persuaded the acid of fat existed ready formed in fat, and was not the product of distillation, he formed a soap with fat and potash, and treated this soap with water, in order to dissolve the sebat of potash formed in it. But as the water, besides the sebat, dissolved also some of the fat combined with potash, he added to the solution of this sebat of potash and of this soap a sufficient quantity of alum, by which he got sebat of potash with only an admixture of sulphat of potash; this he evaporated, poured sulphuric acid upon the dry substance, applied heat, and sebacic acid passed over into the receiver. In the chemistry of Dijon is a different process; the fat is there calcined with lime in a crucible; the substance lixiviated with a large quantity of water; the water holding the calcareous sebat in solution, evaporated; and this calcareous sebat is introduced into a retort with sulphuric acid, and the sebacic acid passes over into the receiver.

These three processes Thenard repeated with great care, and obtained the following results. The first of Crell's processes, and that of the chemistry of Dijon, afforded him an acid that had all the characteristics of the acetous acid; with potash it formed a foliated deliquescent salt, of an extremely pungent savour, and which treated with sulphuric acid gave a large quantity of vinegar. He thinks that if Crell, as he asserts, did obtain a fuming and pungent acid, it was a small quantity of sulphureous acid, proceeding from the decomposition of a certain portion of sulphuric acid, by the fat, or of the carbon of the acetous acid disengaged from it's combination. In making the second process of Crell, Thenard asserts, no acetous acid is obtained, but an acid which is nothing but the muriatic. In fact, it forms with the nitrat of silver a precipitate insoluble in an excess of nitric acid; with soda it forms cubic crystals. If sulphuric acid be poured upon these crystals, a penetrating gas is disengaged, which on being brought into contact with the air, gives rise to vapours; the same acid mixed with nitric acid dissolves gold; with the oxyd of mercury it forms a volatile salt; with potash a salt capable of being fused without undergoing decomposition. These circumstances, according to Thenard, render it probable, that Crell employed the potash of commerce, which always contains muriat of potash, for in repeating this process with pure potash, no acid is obtained, except an almost imperceptible quantity of vinegar. This vinegar is formed by treating the fat with potash and the sulphuric acid, for fat contains no acid, according to this chemist, not even when it is rancid; at least he has several times treated rancid fat with water, and uniformly obtained a liquid, which did not redden the tincture of turnsol.

Recapitulation.

According to Thenard, these experiments prove what he has already advanced, viz. that there exists in the pro-

duct of diſtilled fat a peculiar acid, which, inſtead of being volatile, odorous and ſuffocating, is, on the contrary, ſolid, inodorous, and fixed to a certain degree; that beſides this acid, the product of diſtilled fat contains acetous acid; that the ſebacic acid has no ſhare in producing the ſmell of diſtilled fat, which probably depends upon ſome particles of fat converted into vapour, and altered in their nature. They prove, beſides, that by the proceſſes of Crell, and by that deſcribed in the chemiſtry of Dijon, the muriatic, or the acetous acid, is only obtained; that conſequently, the ſebacic acid has hitherto remained unknown, and that in the preſent ſtate of our knowlege, it is a new acid.

Thenard obſerves, that all the experiments he made was with hog's lard, and that he has not, like Crell, varied them with human fat, the marrow of the ox, and tallow. He concludes, by propoſing to repeat them with theſe different fatty ſubſtances; but expects to obtain ſimilar reſults. He has not yet examined, he ſays, all the properties of the ſebacic acid; but intends to inveſtigate them with care.

For a more exact determination of the affinities of this acid with other ſubſtances, both in the wet and dry way, a nicer examination of the degrees of ſolubility of it's earthy, ſaline, and metallic neutral ſalts, in water, alcohol and other fluids; a further inveſtigation of it in it's gaſeous ſtate, and a future proof, whether, like moſt acids, it forms, with lime, a body which emits light in the dark, muſt be left for future experiments.

Franc. Gruetzmacher, Diſſertat. de Oſſium Medulla. Lipſiæ. 1748.—Jo. Andr. Segner et Dan. Henr. Knape, Diſſert. de Acido Pinguedinis animalis, Goetting. 1754. —Macquer's Chymiſch. Wœrterbuch, von Leonhardi. t. 2. p. 207. Fettſaure Leip. 1701.—Philoſophie Chi-

mique par Fourcroy, ed van Mons, Bruxelles. An. 3.—Marets neuen Verfuchen in Crell's Annal. 1786.—Lorentz Crell's Verfuche mit. der. aus. dem. Rindertalge entwickelten Saure, in his Chem. Journ. Th. 1. 2. 4.—Bergman's Opufcula. 3.—Riechens Erfahrungen, in Crell's Chem. Annal. p. 2. 1786.—Gren in ibid. 1784.—Crell's Zerlegung des Walraths in his Chem. Journ. th. 4.—De la Metherie, vide Rofier's Journal de Phys. p. 43. t. 48.—On the Sebacic Acid, or Acid of Fat, by Cit. Thenard. Annals de Chimie. 39. 193.

ZOONIC ACID.

Zoonic acid. At the article flefh, it appeared, that Thouvenel had mentioned a faline fubftance, which, moft probably, is the acid difcovered by Berthollet, by the name of the zoonic. It is well known, that the liquor extracted by diftillation from animal fubftances, only appeared to contain carbonat of ammonia, and an oil; but Berthollet having detected this acid in it, looks upon it as a product of the diftillation of all animal fubftances.

Difcovered by Berthollet.

Method of procuring it. In order to feparate this acid, the oil is firft taken off, and lime is then mixed with the liquor of diftillation, and the mixture boiled or diftilled. The carbonat of ammonia then exhales, and when the fmell ceafes to be irritating, the liquor is filtered, a little more lime is added to it, and it is again boiled, until the odour of the ammonia intirely difappears. What remains is zoonat of lime, which is again to be filtered. Water impregnated with fixed air is then to be poured upon it, or refpired air is to be paffed through it by means of a tube, to precipitate, by the carbonic acid, the lime held in folution, in an un-

combined ſtate. In order to obtain the zoonic acid pure from the *zoonat of lime* remaining, the water of the *laſt*, well concentrated, is to be mixed with ſome phoſphoric acid, put into a tubulated retort, and diſtilled. The zoonic acid being very little volatile, requires a degree of heat approaching ebullition, to make it paſs over, ſo that the liquor muſt be boiled; if two flaſks are adapted to the retort, none of it paſſes into the ſecond. It appears, that in this proceſs, one portion of the acid is deſtroyed by the action of the heat; for the liquor, during it's ſtate of ebullition, becomes brown, and towards the end of the operation, blackiſh; hence it may be concluded, that this acid contains carbon. Berthollet did not collect the other principles which are diſengaged during the decompoſition.

The zoonic acid has an odour reſembling that of fleſh which is roaſted brown, and in reality is then forming. It's ſavour is auſtere. It reddens very deeply paper tinged with litmus. It effervеſces with alkaline carbonats. It did not appear to form cryſtallizable ſalts, with alkaline earthy baſes. It forms a white precipitate in the water in which acetite of mercury has been diſſolved, and in that of nitrat of lead, ſo that it has a greater affinity to the oxyd of mercury, than the acetous acid, and to the oxyd of lead, than the nitrous acid has. On the nitrat of ſilver it only acts by compound affinity; but the precipitate, in time, becomes brown, which indicates that the precipitate contains hydrogen. The zoonat of potaſh, when calcined, formed no pruſſiat of iron with a ſolution of that metal. It's properties.

There ſeparated from ſome fleſh which Bethollet had kept for a long time putrid a liquor which gave all the properties of acidity, but which was an ammoniacal ſalt with exceſs of acid. This acid, combined with lime, appeared ſimilar to the zoonat of lime; but he had not a

fufficient quantity to prove exactly it's identity with the zoonic acid.

Trommfdorf has reafon to think, that the zoonic acid is nothing but the febacic; but he has not proved it by experiment.

Thenard, having examined the zoonic acid, thinks he has demonftrated that it is nothing but the acetous acid combined with a peculiar animal matter. It appears, however, that a further inveftigation is neceffary before the real nature and properties of this acid can be well underftood.

Notice fur un Acide retiré des Subftances animales, ou acide zoonique, par le Citn. Berthollet. An. de Ch. No. 76. p. 86. 30 Germinal. An. 6.

POISONS.

ANIMAL poisons may be divided into two classes.

1st. Those which are produced by animals in a state of health, and are employed as a means of defence, such as the poison of different species of serpents, and insects. Their division.

2d. Those which are produced by an animal in a state of disease, and are communicated to other animals by means of what is called contagion, such as the poison of the cancer, the hospital sore, the venereal virus, that of the small-pox, measles, and the miasma that arises from the putrefaction of organized substances; but as the little knowledge which chemistry affords us of the nature of this class, is to be found at the articles *pus* and *miasma* the present will only contain a description of the few experiments and observations which have been made, to investigate the chemical principles of the first class.

It is to Francis Redi, a celebrated Italian philosopher, that we are indebted for the discovery of the humour that renders the bite of the viper venomous. The ancients were ignorant of what the venom consisted, and of the part of the animal in which it resided. Redi was the first who established these points. In his treatise on the venom of the viper, it appears, that he found it to be a humour resembling the oil of sweet almonds, which the animal conveys with his tooth into the wound it makes by biting; but he was mistaken in almost every thing else he said on the subject of this poison. Redi.

Mead is the first who in any way examined the nature and qualities of it; according to this physician, the venom is acid, as he informs us it changed the dye of litmus red, and even gave a reddish tinge to the sirup of Mead.

violets. A few years afterward, he retracted every thing he had advanced on the acidity of this liquor, and confeffed it was neither acid nor alkaline.

James. Dr. James, who affures us he repeated the experiments of Mead, found it to be likewife acid; but moft probably he was ignorant of the latter experiments of that phyfician.

Juffieu. Juffieu, perfuaded likewife of the acidity of this venom, upon the authority of Mead, immediately found a fpecific againft it in the volatile alkali; he was not, however, the firft to recommend it's ufe.

The uncertainty and contradiction of the fact of the acidity of this poifon invited Fontana to inveftigate the truth of it; and, "I hope" fays he, "that there will be no longer any doubt, for I flatter myfelf to have difcovered the error into which Mead happened to fall when he firft examined this venom, an errour againft which Doctor James was not able to guard."

He found, though but very rarely, that the venom of the viper gives litmus a light red colour; but in thefe cafes it was not very pure, as he difcovered by the microfcope fome globules of blood floating in it, and on examining the mouth of the viper, he found the two bags or fheaths that cover the teeth flightly inflamed. It appears, that it is not uncommon to meet with thefe animals naturally in this ftate, and it is ftill more common to find the bags reddened after they have bitten. The venom is alfo frequently ftained with blood if it's receptacle be too ftrongly compreffed. All thefe circumftances may take place, and in all of them the litmus may be by thefe means reddened, without fuppofing an acidity in the venom. It is therefore, according to Fontana, not unlikely, that Doctor James had been deceived in the fame manner as Mead, for it is certain, that in the few cafes in which Fontana found the colour of the litmus reddened, the venom was not pure, but mixed with blood.

According to Fontana, the venom of the viper, when pure, appears, when examined by a microfcope, like an oil, of a more or lefs yellow colour. It is contained in a veficle for it's refervoir, which is enclofed in a conftrictor mufcle, fituated in the jaws of the animal; by this mufcle the liquid venom is fqueezed out through an elliptical orifice at the point of it's canine teeth. Fontana.

It is perfectly taftelefs, but leaves on the tongue a fenfation of torpor or ftupefaction on the part it touches; the tongue particularly feels numbed; it even appears to be grown larger, and it's motions are flower and more difficult. Properties of the poifon of the viper.

It neither reddens the tincture of litmus nor the blue juice of radifhes.

In a liquid ftate, it unites more or lefs with acids.

When dry, they have no effect upon it, except that of making it fomewhat tenacious.

Alkalis have no more effect upon it than acids.

Boiling water immediately diffolves it, and lofes no part of it's tranfparency.

Alcohol has no effect upon it,

It is not acted upon by effential oils, or by hepar fulphuris.

It does not melt when expofed to the fire.

Caft upon a red hot coal, it fwells and puffs up, but does not begin to inflame till it has affumed the appearance of a coal.

From obferving that the dried venom appeared to be tenacious, like one of the ftrongeft gums when broken between the teeth; and that it was alfo foluble in water, and not in alcohol, Fontana fufpected it to be a gum; another experiment, however, remained to render this fufpicion decifive.

It is known, that gums diffolved in water are precipitated by fpirit of wine, and the water becomes white.

Fontana, therefore, put equal portions of water into two fmall glaffes; he added to one of them a quantity of the venom, and to the other an equal quantity of gum arabic. The folution of the gum arabic, which was effected by heat, being reduced to the temperature of the liquor in the other glafs, feveral drops of alcohol were poured into each of the glaffes. Immediately a whitifh cloudinefs appeared in both folutions, at every drop of alcohol, and difappeared the moment after. On continuing to add an equal quantity of alcohol to each glafs, the white cloud, inftead of difappearing, extended over the fluids, which became whiter and more opake on every addition of alcohol. On ceafing to add more, the white matter began to precipitate, and a few drops more caufed a perfect feparation. At the end of 24 hours the precipitation was complete, and at the bottom of each glafs was found nearly the fame quantity of an equally white, foft, and pafte-like fubftance.

A drop of venom dried upon a glafs cracks, on drying, from the circumference to the centre, and when diffolved in water, and precipitated by alcohol, falls down in the form of a white powder or meal; this if dried afrefh cracks in different parts, and it's fiffures are of the ufual reticular form.

If clear and tranfparent vitriolic acid be mixed with the precipitated and dried venom, at the end of a certain time, it becomes of a dark vinous colour. The fame changes are obferved in the folution of gum arabic in water precipitated by alcohol. This gum, in drying, likewife adheres to the glafs, and cracks; and if a few drops of vitriolic acid be added, they become, in the fame fpace of time, of a dark vinous colour.

The analogy, therefore, between the venom and the gum, according to Fontana, cannot be more perfect. They are both foluble in water, both precipitated in the

ſame way by alcohol; the precipitated powder or meal is of the ſame colour; both of them crack on drying; vitriolic acid does not ſoften them till after ſome time, and the colour is changed in the ſame manner with each of theſe ſubſtances. As a further proof that this venom has a great analogy to the gums, Fontana made another experiment. He put ſix grains of very pure dried venom into a ſmall matraſs, and added 50 drops of nitrous acid. By the aſſiſtance of heat there aroſe as much air, or perhaps more than the matraſs could contain. This was common air ſomewhat changed in it's qualities. The heat being continued, a clouded air aroſe, which on examination was found to be compoſed of one third of fixed, and two thirds of phlogiſtic air.

Gum arabic under the ſame circumſtances likewiſe afforded fixed and phlogiſtic airs, and the reſults of both experiments were ſo perfectly ſimilar, that they might have been confounded together. According to Fontana, gum arabic likewiſe affords nitrous air, but this only happens when in conſiderable quantity. If the quantity be very ſmall, the little nitrous air it affords is decompoſed, and unites to the common air in the matraſs.

Hence Fontana looks upon the venom of the viper to be a real animal gum, poſſeſſing all the properties and principal characteriſtics of a gum, and the only one of the animal kind that is at preſent known. An animal gum.

From the experiments and obſervations of Dr. Ruſſel, it appears, that the poiſons of the different ſpecies of ſerpents are very analogous to each other. Ruſſel.

When firſt emitted, they are ſomewhat mucilaginous, but become more ſo on expoſure to the air; the colour, from a pale yellowiſh white, becomes more yellow, and when dry, they reſemble a yellow flaky reſin. Kept for ſome time their colour becomes darker, and they loſe ſomewhat of their ſolubility; for when recent, according to this

phyſician, or in the intermediate degrees of exſiccation, they readily mix either with water or ſpirit. He informs us, that a drop or two of the poiſons of the ſerpents called the Cobra de Capello and Katuka Rekula Poda had no taſte, nor produced any effect on the tongue or palate, and that when inveſtigated with the uſual teſts ſhowed no indication of being either acid or alkaline.

Two drops of the recent poiſon of the katuka rekula poda, diluted with four drops of ſpring water, were put into a wine glaſs, No. 1; and ſix drops of water into another glaſs, No. 2; into each glaſs was then permitted to fall a tea ſpoonful of blood from the neck of a chicken, juſt decapitated. Both mixtures being ſtirred for five minutes, with ſmooth ſticks, were left to ſettle. The blood in No. 1 appeared of a colour conſiderably darker than that in the other, and a clot was found adhering to the point of the ſtick, of a darker colour, and more grumous conſiſtence than ordinary. To the ſtick belonging to No. 2 a much ſmaller clot adhered, of a brighter colour, and more looſe contexture. After ſtanding three hours, the difference was more remarkable; the blood in No. 1 remained uncoagulated, and much blacker, with a little livid coloured ſerum above; in No. 2 it nearly retained it's primitive colour; the craſſamentum was formed, and a little ſerum of the uſual colour remained at top. On repeating this experiment, the glaſſes were carefully warmed, and the mixtures ſtirred only one minute. Very little blood was found adhering to the ſticks. The ſame alteration in colour was obſerved as before; but the blood in No. 1 was leſs fluid than in the former experiment, though ſtill much more ſo than in the glaſs No. 2.

Before the experiments of Fontana, no chemiſt had examined with any attention the liquor with which thoſe inſects are provided that wound with a ſting, ſuch as the ſcorpion, bee, waſp, &c. Indeed Mead ſays, he found

the humour of the bee to be compofed of very fine faline needles or points; he affures us he had examined it with a microfcope, and found it full of thefe pointed falts. Fontana has, however, proved, that Mead was as much miftaken in thefe obfervations as he was in his experiments on the venom of the viper.

We are informed by Fontana that the poifon of the bee, like that of the venom of the viper, cracks on drying, and prefents the ufual fharp and regular fragments, which were fufficient to perfuade Mead of it's being a real falt. Venom of the bee.

When the venoms of the viper and the bee are dried and examined through the lens of a microfcope, no fenfible difference is to be obferved between them; he however found that the venom of the bee, expofed to the open air upon a piece of glafs, was much longer in drying than that of the viper, and that the cracks and fiffures in the former were formed much later than thofe in the latter, fuppofing the degree of exficcation of the two fluids alike.

Thefe two poifons not only agree in the appearances their parts prefent in drying, but likewife in other properties. Thus, if a piece of the dried venom of the bee be ftrongly compreffed between the teeth, it glues them as it were faft together; and the fame takes place with the venom of the viper and all exficcated gummy fubftances.

The dried venom of the bee is alfo foluble in water, and refifts the action of alcohol like them; hence Fontana is inclined to add the venom of the bee to the clafs of animal gums, but the quantity capable of being collected he found fo very fmall, as fcarcely to render any experiments on this fubject certain.

This celebrated philofopher has likewife examined the poifon of the fcorpion, which is acrid and pungent, and Of the fcorpion.

alſo that of the waſp, and other inſects in general, that wound with a ſting. In all theſe he found this humour to have a hot, bitter and acrid taſte, and to poſſeſs all the characters of a gum. It cracked, when left to dry on glaſs, like that of the viper, and when chewed was tenacious, glutinous and elaſtic.

The humour, however, of theſe inſects, is not to be conſidered as the ſame as that of the viper, and to poſſeſs all it's qualities. It has been obſerved before, that the venom of the viper has neither any ſenſible taſte, nor is ſufficiently acid to tinge red the tincture of litmus, although ſo ſenſible is this teſt, that $\frac{1}{22380}$ part of a grain of fixed air is able evidently to redden one grain of the dye of litmus. The moment, however, the humour of the inſect is applied to a piece of paper ſtained with radiſh juice, a ſlight red tinge appears, which afterwards changes to a pale yellow; ſo that it appears this humour is united to an acid principle, although in ſuch a manner as not to occaſion the ſmalleſt acid ſenſation on the organs of taſte.

From the experiments of this chemiſt, therefore, we are led to regard the hypotheſis of thoſe phyſicians who have advanced that the venom of the viper is an acid, and that volatile alkali is a ſpecific remedy by neutralizing the acid, as falſe and erroneous, and that theſe poiſons act on the body of animals in a manner which is not at preſent within the reach of the human mind to penetrate.

Sur les Poiſons et ſur le Corps Animal, par M. Fontana, 2 T. 1781.—An account of Indian Serpents, &c. by Patrick Ruſſel, M. D. F. R. S. fol. London, 1796.

AROMATA.

Animal aroma.

The ſmall volatile particles which are conſtantly flying off from animals and animal ſubſtances at the common temperature of the atmoſphere, and which affect more or leſs the organs of ſmell, conſtitute what are called animal odours or aromata. Theſe aromata, on ſubjecting theſe ſubſtances to a gentle diſtillation, generally come over along with the aqueous portion; there are, however, a few in which the want of volatility of the odorous particles oblige them to remain in great meaſure behind. In living animals the aroma forms the ſcent of the particular ſpecies, and is the means by which the huntſman is enabled to purſue his game, and the dog to trace the footſteps of his maſter. It was even the opinion of Vitoſt that not only every animal has it's peculiar odour, but that it is different in each of it's parts. In ſome bodies it is ſo very evident as to form a diſtinguiſhing character, in others the niceſt and moſt experienced organs are ſcarcely able to find a difference. It is often made uſe of as the means by which connoiſſeurs are enabled to judge of the ſlighteſt imperfection or taint of the ſubſtance under examination, whether of the different tribes of animals, or of parts of them which have been preſerved, as bacon, cheeſe, &c. from which it would appear that theſe odorous particles depend upon the peculiar component parts of the animal matter. In certain parts of ſome animals this aroma ſeems to be more particularly concentrated, and appears to have been either ſecreted for ſome unknown particular purpoſe, or is merely an excrement; of theſe there are four which have undergone ſome ſlight chemical inveſtigation, viz. *Ambergris*, *Caſtor*, *Civet* and *Muſk*, all of which are the products of the mammalia claſs. The ſtrong, tenacious, aromatic odour which conſtitutes

the more remarkable characters of these substances, appears, however, not to be peculiar to them alone, but seems as it were to form a *genus of aromata* in nature, since many substances offer one analogous to them, more particularly resembling that of ambergris and musk. It is found in some insects, and in a number of the labiated plants, and the elaboratories of chemistry, where animal substances have been analyzed, often give occasion of observing the very same aroma. Morveau has observed also, that urine when brought to an extract, the salts of urine when moistened, and the human bile and that of the ox, when kept for a certain time, emit an odour of this species so strong as to have deceived several people, who could not believe the origin of these singular perfumes. Likewise in bilious diseases, the perspiration has been sometimes found to possess this odorous character. The dung of the cow, Morveau informs us, has the same property, and by distilling alcohol upon this excrementitious matter, an aromatic liquor is prepared by the name of *eau de mille fleurs*. It would appear that this odour, whether naturally or artificially procured, is owing to some principle which chemistry is yet ignorant of.

AMBERGRIS.

Ambergris. AMBERGRIS is a concrete matter of a soft and tenacious consistence like wax, or solid and breaking like the gum resins; it is of a gray colour marked with yellow or black spots, and when heated or rubbed, has an agreeable and peculiarly strong aroma, which, however, to some people is unpleasant. The older it has been kept the more agreeable is the aroma, and it's consistence, according to Swediaur, depends upon it's having been exposed to a more or less warm air. It is called by the later

Greek writers, *ambar*, by the Latins *ambra grifea* or *ambarum*; and fometimes, as Fallopius has written it, *ambraca*. It is called by the French *ambregris* or *ambre*, and by the Germans *ambra* or *grauer ambra*.

Under the title amber the ancients comprehended another fubftance, very different in it's nature and properties from this. It is known by the name of *yellow amber*, and is a fpecies of bitumen; it was called by the ancient Greeks ηλεκτρον; by the Arabs *karabe*; by the Latins *ambra flava* or *fuccinum*; by the French it is named *ambre jaune*, *citrin* or *fuccin*; and by the Germans *agtftein* or *bernftein*. Differs from amber.

Naturalifts have diftinguifhed feveral varieties of ambergris. Wallerius mentions fix.

1. Ambergris with yellow fpots } Thefe are the moft precious. Varieties of ambergris.
2. ——— with black fpots }
3. White.
4. Yellow.
5. Brown.
6. Black.

Thefe varieties depend on the mixture of certain marine fubftances which they contain. It is found in irregular, fometimes globular maffes, confifting of ftrata of different kinds, and more or lefs thick according to the number united. Pieces have been found of more than 200 lb. weight. It has evidently been in a liquid ftate, as it envelops many foreign matters, fuch as fquids, or the bones of the cuttle and other fifh, foffil fhells and other marine bodies.

It is found floating on the fea near the Molucca Iflands, Madagafcar and Sumatra, likewife on the coafts of Coromandel, Brafil, and on thofe of Africa, China and Japan. It is feldom found in large pieces, although it is related that Lockner faw one of 42, and Kæmpfer another that weighed 130 pounds. Where found.

The ftate of analyfis of this fubftance is very imperfect; fome experiments were made upon it many years ago by It's diftillation.

Geoffrey, Neumann, Grim and Brown, but they are very imperfect. We learn from them, that the ſtrong aroma of ambergris is communicated to the water which ariſes on diſtillation: that in a moderate heat, it melts like wax, and then reſembles a thickiſh blackiſh oil, exhales vapours, foams, and at length entirely evaporates; that in the flame of a candle it inflames and burns away with a clear flame. By the dry diſtillation it affords a ſouriſh water, a little fixed ſalt, and ſome oil.

According to Hagen, it is not ſoluble in water but is in alcohol, and ſtill more ſo in the vitriolic æther.

A more exact analyſis of ambergris has been made by Vauquelin and Bouvier upon a variety ſent them by Macquart. This was the *black* variety. It was compoſed of ſtrata of different colours and thickneſs. In certain parts, white cryſtals were evident; they were iſolated. It's odour was ſtrong and diſagreeable, reſembling in ſome reſpect the urine of the mare; this was more particularly ſo with the ſalt obtained by the evaporation of this fluid. It was ſpecifically lighter than water.

Water. Fifty parts of this pulverized ambergris were boiled in two oz. of diſtilled water for 10 minutes, the odour which aroſe was much leſs diſagreeable than that from the ſolid ſubſtance. It tinged the water of a deep ſtraw colour; at 60° it melted and ſwam upon the ſurface, and was of a ſemipellucid brown colour. The filtered liquor produced no change upon ſirup of violets. On evaporation, nearly two grains of a yellow product were obtained of a ſharp and ſaline ſavour, mixed with cryſtals of common ſalt. The ſolution changed the ſirup of violets green.

Alcohol. Boiling alcohol diſſolved a great part of the reſiduum, became of a deep brown colour, and the black grumous matter remaining, being treated a ſecond time with alcohol, became yellow, but it did not diſſolve it. The reſi-

duum, which was almoſt entirely formed of membranous matter, dried and put on red coals, produced a yellow, fetid, ammoniacal ſmoke.

On cooling, the alcohol depoſited a great part of what it had taken up.

A portion of this reſiduum on diſtillation afforded a red oil extremely fetid, and exactly ſimilar to that of other matters, and ſome carbonat of ammonia.

From it's treatment with alcohol, it appears that the aromatic part does not reſide in the reſinous part of the ambergris. The brown membranous parts of it preſented many of the characters of animal matter, although their coal being not light, made them approach to the algæ which have ſome reſemblance to animal matters. Are they therefore, it has been aſked, animal membranes, or remnants of the fuci?

The cryſtals found in the ambergris appeared to be a mixture of ſand and calcareous earth.

Oxygenated muriatic acid poured upon a portion of the alcoholine reſin of the ambergris, took away it's brown colour, but did not perfectly whiten it; it remained yellowiſh and loſt it's odour, and the ſame happened to the acid. It's conſiſtence however was not changed. Oxygenated muriatic acid.

Well rectified ether diſſolved the greateſt part of the ambergris, which had been previouſly treated with boiling water. The reſiduum was black and grumous, but afforded no pellicles, as was the caſe with the alcohol. The ſpontaneous evaporation of the ether from the reſinous part weakened the odour of the reſiduum by raiſing it into the atmoſphere. Ether.

Thirty parts of oxyd of ſilver and three parts of the reſin, by a gentle heat, afforded from ſix to ſeven inches of carbonic acid gas, without any mixture of hydrogen gas. In the tube of the apparatus ſeveral clear and tranſparent drops of water were obſerved, and the ſilver being re- Oxyd of ſilver.

duced weighed 21 grains. This experiment upon larger quantities might perhaps give the proportions of the principles of this refin, or at leaft of the hydrogen and carbon which form it's bafis. It might be even poffible to come at it's quantity of oxygen by exactly knowing that of the oxyd of filver.

Expofed to fire.

Thirty fix grains of this ambergris expofed to the fire in an open crucible foon became foft and melted; on increafing the heat a few degrees, it inflamed; the flame was at firft yellow and white, and the fmell difagreeable. The fmoke foon ceafing, the flame became more clear and brilliant, with an odour refembling that from burning maftic or olibanum, depofiting carbon extremely divided, as is the cafe with odorous fubftances. The refiduum was three grains and a half of white matter in very diftinct hard grains, the greater part of which was fand and carbonat of lime.

No more traces were found of carbonat of foda or common falt, and thefe chemifts feem to think that they were volatilized by the heat, fince the edulcoration of the ambergris afforded them by a gentle evaporation.

Ufe.

Ambergris is employed in medicine, but it's greateft ufe is as a perfume mixed with mufk, the aroma of which it fo attenuates as to render it milder and more fupportable.

Characters of pure ambergris.

As this fubftance is very dear, it is often falfified and mixed with different fubftances. The real ambergris has the following character: it is flaky, infipid to the tafte, of a fweet odour; expofed to the flame of a candle in a filver fpoon it melts without fcum or bubbles. It floats upon water, and does not adhere to a red-hot iron; that which does not poffefs thefe properties is adulterated and impure.

ORIGIN OF AMBERGRIS.

Different opinions.

NATURAL hiftorians and chemifts have been very much divided refpecting the origin of ambergris. The greater number have looked upon it as a bitumen, a fort of petroleum, that iffued from the rocks, and was condenfed by means of the fun and the action of the falt water. Cartheufar made no doubt of it's being of this nature, and what confirmed him in this opinion was the analyfis of it by the chemifts, particularly by Neumann, who got the fame component parts from it as from amber, viz. phlegm, a volatile acid, partly fluid, partly fixed, an oil, and a little carbonaceous matter. Macquer, however, obferves, that it differs from common amber by being far lefs hard, and not fmooth or able to take any polifh; it is likewife opake and fufible; that it is alfo rendered fofter even by the heat of the hand, like wax. Likewife on diftillation it leaves much lefs carbonaceous matter, from which it appears to him to be of a much more oily nature than common amber.

Cartheufar.

Ambergris has been likewife fuppofed to be of vegetable origin. Aublet affirms, (Hiftoire des Plantes de la Gujane, 1774) that it is nothing but the juice of a tree in Guiana infpiffated by evaporation; that this tree is called cuma, and by Linnæus, amyris ambroifiaca; that the river wafhes pieces of it into the river, that Rouelle has examined many of thefe pieces and found them to agree perfectly with ambergris in their properties. Rumph has alfo noted a tree called nanarium which affords fuch a juice. Bergman was alfo of opinion that it was of vegetable origin. Pliny in old times was of the fame opinion.

Aublet.

Some, on the contrary, have fuppofed it to be the excrement of birds that live upon odoriferous herbs, and

others have attributed it's origin to the matter rendered by the fea cow, or the excrement of the crocodile, &c.

Pomet and Lemery.

Pomet and Lemery believed it to be a mixture of wax and honey roafted by the action of the fun; and Fourcroy, who adopted the fame opinion, fays, that a product very analogous to that of ambergreafe may be obtained from thefe two fubftances.

Some Englifh authors have looked upon it as an animal juice depofited in facs placed near the organs of generation in the male whale; and others, think that it was formed in the urinary bladder of that animal; but both thefe opinions are contradicted by the beaks of the cuttle fifh being found in this concrete juice. At length, Dr. Swediaur, a Swede, after having examined a great number of

Swediaur.

fpecimens of ambergreafe, and the accounts of feveveral navigators, looks upon it to be formed in the alimentary canal of the phyfeter macrocephalus, a fpecies of whale from which the fpermaceti is extracted. He confiders it as an indurated excrement mixed with certain parts of it's aliment, or a kind of bezoard of this cetaceous animal. He grounds his opinion on the following circumftances:

1ft. Becaufe fifhermen find ambergreafe in this whale.

2d. Becaufe ambergreafe is common in thofe regions frequented by this whale.

3d. Becaufe the beak or chops of the fepia octopedia on which the animal feeds is always found in it.

4th. Becaufe he difcovered the black fpots in this concrete fubftance to be the feet of this polypus.

5th. Finally becaufe the excrements of feveral quadrupeds, fuch as cows, pigs, &c. after being kept a certain time exhale an odour analogous to that of ambergreafe.

The inquiries of this phyfician have rendered this opinion of the Japanefe and of Kæmpfer very reafonable; and nothing, fays Fourcroy, is wanting to it's entire confir-

mation, but the obſervation of ſome real naturaliſt made upon the ſpot.

It has been ſeen, however, that this ſubſtance analyzed by Geoffroy, Neumann, Grim, and Brown, afforded the ſame principles as bitumens, *i. e.* an acid ſpirit, a concrete acid ſalt oil, and a carbonaceous reſiduum, which induced them to rank it amongſt thoſe bodies. To this Swediaur obſerves, very truly, that the calculi of animals likewiſe afford an acid, and that the preſence of this ſalt is a proof in favour of his opinion, ſince fats contain it alſo in conſiderable quantity.

This phyſician has likewiſe been informed by ſeveral American fiſhermen, that they have found ambergris very often, either amongſt the excrements of the phyſeter macrocephalus of Linneus, or in it's ſtomach, or in a pocket, which they ſay is ſituate near the viſcera, probably the cæcum.

In ſupport of the opinion of Swediaur, it may be added, that according to the teſtimony of Coffin, who was examined before the committee reſpecting ambergris, it appears, that the ſpermaceti whale, who lives on this polypus, or what the ſailors call ſquids, evacuates his excrement on being ſtruck with the harpoon; and if this does not take place, they conjecture there is ſome ambergris in his belly, looking upon this ſubſtance to be either the cauſe or effect of diſeaſe. Such are the reaſons why this ſubſtance may be ranked amongſt the reſinous and odoriferous matters of the animal kingdom.

In oppoſition to the opinion of Swediaur, Dandrada, a Braſilian, publiſhed an account of the origin of this ſubſtance; who, after having obſerved, that it is only upon account of the chops of the cuttle-fiſh, that Swediaur has founded his opinion, thus continues his narrative, which is extracted from Fourcroy's account in the Encyclop. Méthodique. Dandrada.

"Kæmpfer thought, after the Japanese, that ambergris was an excrement from the whale; and the opinion of Swediaur is only a modification of it. The natives of Brasil, at the time of it's discovery, were of the same sentiment; but whoever will take the trouble to examine the grounds on which it is supported, and the places where it is found, will be convinced of the contrary."

If ambergris was the excrement of the diseased whale, it would be found in all the places where it frequents, but on the contrary, it is only found on some shores of the warmer climates, as at Madagascar, the islands of Cape Verd, Japan, China, the Brasil Islands, &c. In this last country, it is only to be met with on some of the shores and bays, principally at the mouth of the river Camouci, in the precincts of the territory of Maragnon, and in the bay of All Saints. From 20° of south latitude, to the river Plata, it is never met with. Now, it is at Santo, the country of Dandrada, situate at 24° of south latitude, and at Santa Catherina, still more to the south, that the whale is caught.

According to Dandrada, ambergris is not an excrement, since, at Brasil, it has been several times extracted from the stomach of the whale.

Magalhaens Gandavo affirms in his history of Brasil, printed at Lisbon in 1576, that some whales had been dissected on purpose, and that pieces of ambergris had been found in the stomach of one of them, and some in the intestines, that were become more soft. All this is lately confirmed in the Courier de l'Europe, for the 11th of January, 1791, which relates, that the vessel, the Lord Hawkesbury, had lately caught a whale, from the œsophagus of which, it is said, 400 ounces of ambergris have been extracted.

Besides, if it was an excrement unnaturally hardened, as is the opinion of Swediaur, it would neither be found

in ſtrata, which are almoſt always horizontal, of unequal ſize, and ſometimes even different in their nature. It is obſerved by Bomare, that the ambergris he examined, from the eaſt, was compoſed of ſtrata, of which the ſecond was inodorous, calcareous, and ſaline. If there are ſome pieces that have ſpots, and the chops of the cuttle-fiſh, there are likewiſe many that are homogeneous, and without ſpots; and even Pelletier ſhowed a piece, at one of the ſittings of the Society of Natural Hiſtory, at Paris, that contained ſome ſmall ſhells. It is probable thoſe pieces that contain the beaks, are the ſame that had been ſwallowed by the whale.

Why, aſks Dandrada, are they only found on the ſhores after tempeſts? and why are not the other hard excrements of the ſame fiſh found at the ſame time? and why is it only ſoft ambergris, and without conſiſtence? That of the ſhores is likewiſe leſs coloured than that taken from the whale, which ought to be the reverſe, according to Swediaur's opinion, ſince this muſt have been expoſed a longer time to the heat and light.

It is related by an author of an ancient Portugueſe manuſcript, on the moſt remarkable things of Braſil, for the year 1680, that one of his friends, Antonio Gil, had ſhown him a marine ſpring in the iſland of Tapaiica, in the bay of All Saints, which, when the ſea was low, appeared viſible, where he had ſeen ambergris ſpring up and increaſe between the rocks near it. Simoneus de Vaſconcello, ſuperior of the Jeſuits of Braſil, affirms, in his introduction to the chronicle of that province, printed at Liſbon, in 1720, that at Taparica foſſil ambergris was to be met with. Now, all theſe obſervations and authorities, ſays Dandrada, are abſolutely contrary to the hypotheſis of Swediaur.

The analyſis of Geoffroy, Neumann, Grim, and Brown, although imperfect, conſtantly afforded them the

P 2

ſame liquid and concrete acid, ſome oil, and charcoal; but if ambergris was an excrement of this fiſh, it ought to have afforded ammonia, and other products of animal ſubſtances; for all the other excrements of the mammalia tribes afford it. Theſe chemiſts likewiſe ſay, that the acid they obtained from it was the ſame as from bitumens, *i. e.* the ſuccinic acid. Some chemiſts affirm it to be of animal origin, from it's odour; but this odour, unfolded by the action of air and light, and which increaſes by age, muſt not be confounded with that of the bile, the calculi of which are round, and cryſtallized in concentric ſtrata. This hypotheſis may likewiſe be defended by the obſervation of Romé de Liſle (Journ. de Phy. v. 2. 1784) who ſays, that the ſepia octopedia, Lin. or the polypus octopus of Rondelet, was called by the ancients, according to Rondelet, eladone, d'ozaina, and d'oſmylus, becauſe this kind *ſmells well.* That the modern Greeks call it moſchytis, becauſe it ſmells like *muſk*, and not only when alive, but when dead and dried.

Now is it not infinitely probable, ſays Romé de Liſle, that the muſky odour of this polypus contributes to form that of the ambergris, becauſe it is found in whales that eat this kind of polypus; and that ambergris, or at leaſt it's odoriferous baſis, ariſes from this digeſted polypus? But Dandrada obſerves,

1ſt. That this appearance, from what has been ſaid, is not probable.

2d. That it is neceſſary to diſtinguiſh this muſky odour from that of the ambergris.

3d. That as this polypus affords a very black colour, it would undoubtedly blacken all the pieces of ambergris.

4th. That at Braſil, where ambergris is found, theſe polypi are very rare, and on the contrary, they are very abundant in other parts frequented by the whale, where no ambergris is to be found.

But what, ſays the ſame author, is the nature and origin of ambergris? After what has been ſaid, and conſidering the property which it has of adhering to the knife when cut, like wax, and ſoft bitumens, and from it's inflammability, and fuſion into a thick and blackiſh oil, it appears, ſays Dandrada, we may run the hazard of ſaying, that it is a kind of ſubmarine bitumen, peculiar to warm climates, which being thrown by the waves on the ſhore, becomes hardened; that this bitumen is ſometimes ſwallowed by the whale, and others of the cetaceous tribes, which not being able to digeſt it, part with it more or leſs changed, along with their other excrements. That the ambergris found by Donadei, on the ſea ſhores on the coaſts of Guinea, which was ſoft and viſcous, and of an odour which he called ſtrongly reſinous, and which it loſt after a certain time, and becomes ſolid, is not againſt my opinion, it came from the iſlands of Cape Verd, or the Canaries, as well as the pumice-ſtones of theſe iſlands, to be met with on the coaſts of Gaſcony, and which have been driven there by the currents of the ocean and Mediterranean. The complete analyſis of this ſubſtance, and the more numerous obſervations which I intend to make at the Braſils and the iſlands of the Cape, may, perhaps, put this matter in every poſſible light.

This celebrated chemiſt contends, that in ſpite of Dandrada's obſervations and reflections, he is far from having proved that ambergris is a bitumen analogous to amber, jet, or common coal, &c. On the one ſide, there is too great a difference between this ſubſtance and the real bitumens; on the other, too great an analogy between the properties of ambergris and a great number of ſubſtances that are odorous, or ſuſceptible of becoming ſo by ſucceſſive alterations, to adopt his opinion. It is not ſo improbable Fourcroy.

to think, that even the matter of the body of the ſepia octopedia, may contribute to it's formation. The Indian ink, which is made, as we are informed, from the black juice of this polypus, affords a very ſtrong odour of ambergris. One of the varieties of ambergris is of a black colour, and very ſtrongly aromatic, it reſembles a black thick juice, and animal membranes are even found it, nor is it rejected by the perfumers.

Ambergris was only known in France, as coming from the two Indies. In the Journal de Phyſique, for May, 1790, Donadei certified that this ſubſtance likewiſe belonged to the coaſt of Gaſcony; and it's exiſtence on this coaſt appeared to him to confirm the reſearches of Doctor Swediaur, by which he proves that ambergris is an animal production belonging to the whale.

It appears, that Dandrada, in one of the latter ſittings of the ſociety, was of a contrary opinion; he ſuppoſed it to be a ſpecimen of bitumen ariſing from ſome ſubmarine volcano, and conſequently he looks upon it as a mineral ſubſtance. If this opinion be true, the gulf of Gaſcony only owes it's ambergris to the iſlands of the Azores; thoſe of Cape Verd, and the Canaries, tend by very violent currents towards the coaſt of Barbary. Chemical analyſis only can decide this queſtion. As to Fourcroy, he looks upon it as an animal ſubſtance.

1ſt. From the urinous odour it exhales when freſh caſt upon the coaſt; it is then pretty ſoft and viſcous.

2d. From the avidity with which the ſea birds ſearch for it. Theſe live only on fiſh. The horizontal and various ſhaded ſtrata of the different pieces of ambergris, cannot be a proof of Dandrada's ſyſtem; on the contrary, a ſubſtance caſt into a denſer fluid, and which does not diſſolve it, cannot form any horizontal ſtrata; and this is not the caſe where this ſubſtance may eaſily increaſe by

ſtrata: as to their ſhades, the antiquity of it's ſtrata, and the different places in which the animal has lived, may occaſion them.

The ſhells, the jaws, of the ſepia octopedia, and the other bodies found in it, can only be foreign to it's nature, and have been united to it at the edges of the coaſt where this ſubſtance, ſtill ſoft, is caſt about and rubbed by the waves.

Laſtly, if uniting the two opinions, ambergris was really a bitumen, which had need of ſojourning ſome time in the body of the whale to acquire all it's properties, the queſtion would be very difficult to reſolve; he therefore looks upon it as a ſort of bezoar, and the yellow part as having much analogy to the bile. The beſt ambergris has a gray ground with ſmall yellow ſpots.

According to Fourcroy, the phyſical properties of ambergris, and it's analyſis, do not indicate that it is of animal origin; they rather ſeem to announce it to be a factitious compoſition of vegetable reſins, of animal pellicles or membranes, and of a certain quantity of the excrement of ſome quadruped, particularly that of the horſe, to which it's odour is owing, ſince this odour is the ſame as that of the ſalts and extract of the urine of that animal.

From theſe details it appears we are far from knowing the intimate nature and properties of ambergris, and of determining it's origin with preciſion. It is for chemical analyſis alone to pronounce on this intereſting object. Till then, it has been placed, with Hildebrandt, amongſt the animal ſubſtances.

Hagen von der Auflöſung des Grauen Ambers in Vitriolæther, in Crell's Chemiſch. Annal. t. 11. ſ. 99. 1784.—Caſper Neumann, Diſquiſitio de Ambra. Dreſd. 1736.—Information of the origin of Ambergris. Phi-

losoph. Transf. part 1. 1791.—Encyclop. Méthod. article Ambre-gris, by Fourcroy.—Neue Zusætze und Anmerkungen zu Macquer's Chym. Wœrterb. von Leonhardi. Erst. B. p.124.—Graue Amber.

CASTOR.

Castor.

This animal substance, when fresh and just taken from the animal, is soft, and nearly in a fluid state; it is of a yellowish colour. By drying in the atmosphere, it assumes, in time, a resinous friable consistence, and becomes of a much darker and brownish colour. In this last state it is generally met with at the shops. It has an acrid, bitter, nauseous savour, and it's odour is strong, aromatic, and even fetid, which it communicates to the water extracted from it.

Examined by de la Grange.

For the best analysis of this substance we are indebted to de la Grange; he found, that two ounces of it macerated in water, at the temperature of 60° for 12 hours, became considerably softened, and gave the water a pale yellow colour.

This water changed the blue colour of vegetables to a green, and when exsiccated, it was soluble in alcohol, effervesced with acids, and was deliquescent.

Having macerated some castor in water, at 40°, for 24 hours, it divided into an infinity of small particles, the water became whitish, and covered with a brown oily pellicle, perfectly soluble in alcohol. Having added one drachm of carbonat of potash in a deliquescent state, to four ounces of this liquor, the mixture presented a very curious phenomenon. It formed three very distinct parts, viz. red, limpid, and whitish. Having separated and exsiccated these three liquors,

The *red* part afforded a fubftance of a deep gray colour, one part of which was attracted by the magnet, and foluble in muriatic acid. Expofed in a crucible to a red heat, 12 grains of iron and 6 grains of earth were obtained.

The *limpid* part afforded an alkaline matter that had all the properties of carbonat of potafh.

The *whitifh* part afforded an earthy fubftance fomewhat alkaline, which earth appeared to be calcareous.

Some caftor macerated in water four days in a fand bath, afforded a fluid of a much deeper colour, and on evaporation, a dry extract was obtained of a beautiful tortoifefhell colour. This extract was foluble in alcohol and in fulphuric ether.

From the alcoholine folution was precipitated by diftilled water, a refinous fubftance, fwelling and inflaming in the fire. This extract was alfo partly foluble in water. The liquor changes the blue colours of vegetables to a green, and becomes, according to Fourcroy and Chaptal, a partly extractive gelatinous mucilage.

The muriatic, nitric, and acetous acids, have no action on caftor.

If caftor be mixed with quicklime, and a little water be added, a lively effervefcence takes place, and there arifes a very ftrong ammoniacal odour. Carbonat of ammonia was extracted from it.

Caftor decompofes the metallic falts, which, according to de la Grange, is a further proof of it's containing a pure alkaline matter.

It's decompofition by the retort affords nothing in particular. The carbon obtained after the operation, expofed on red hot coals, burns with a flame, and fwells confiderably. The nitric acid totally diffolves it.

Hence may be obtained from caftor, according to this

chemist, carbonat of potash, a calcareous earth, iron, and pure resin, an extractive gelatinous mucilage, a volatile essential oil, and carbonat of ammonia.

Fourcroy.

According to Fourcroy, castor consists of a coloured resinous matter, soluble in alcohol or ether, together with a gelatinous mucilage, and an extractive matter, taken up by water; and likewise a solid, which crystallizes in the aqueous solution by evaporation, but the nature of which has not yet been examined. The resin of castor, in which it's whole virtue resides, appears to be analogous to that of the bile. It has not yet been accurately analyzed; it is only ascertained that it affords a small quantity of essential oil, and volatile alkali by distillation; and that the several matters of which it is composed, may be separated by means of ether, alcohol, and water.

The produce of the beaver.

According to de la Grange, the beaver, or amphibious animal from which castor is extracted, was called by the ancients fibrum, the end or extremity of something; and that it is pretended castor takes it's name from the edge or shore of the water where this animal generally lives. Others are of opinion it comes from the greek word φιβρος. The Latins called it Fiber.

This production, which the beaver affords, is the cause of the continual war which man has waged against this innocent, peaceable, and industrious animal, whose manner of living, and state of society, as Buffon says, is a proof of the great perfection he has attained in civilization, and is described with all the elegance and eloquence of that author.

The castor is taken from the inguinal region, where are to be found four bags of an oval shape, a large and a small one on each side. In the two larger bags is the real castor. The two smaller contain a softer and more unctuous fatty matter, of the same kind of smell as that of castor, which is used by the hunters as a decoy for foxes and

other wild beafts of prey, which purfue the beaver by the fcent. It is brought from different countries, but particularly from Poland, Ruffia, the Eaft and Weft Indies, and in America, from Canada, more particularly. This laft fubftance is fometimes fold for real caftor. Manufactures of this drug are formed in feveral places, and there is one at Frankfort.

Difference between true and falfe caftor.

This fubftance is fo well imitated, both as to it's odour and form, that without a particular and attentive examination it would be difficult to find out the difference unlefs by analyfis. We are told by Neumann, that the caftor of the full grown beaver is preferable to that of the younger, and hence the large bags are the beft. From it's being fo fcarce, it is often adulterated. It is ufual to open the facks, and having emptied them, to replace the caftor by a compofition of dried and powdered blood, gum ammonia, galbanum, wax, refin, &c. with a little powdered caftor and the inguinal fat of the animal; they are then glued up again by ifinglafs fo dextroufly as not to be detected.

According to de la Grange, the real caftor has a more penetrating odour, the bags are a little more pointed, and clofed above by a ligament enveloped with the fat of the animal; two bags are generally found united by the fame ligament. If thefe bags be opened, fome filaments are to be diftinguifhed by a lens, fome of which are whitifh, others reddifh, united tranfverfely. The falfe, on the contrary, is more widened above, and appears as if fewed, whilft the interim only prefents a fpecies of pafte, in which a little real caftor has been put, but there are none of the filaments to be feen.

Obfervations fur la Caftor, par Monf. de la Grange, Journal de Phys. fem. 1. p. 65. 1792.—Neumann's Chemiftry, vol. 2. p. 428. and Fourcroy's Elements.

CIVET.

Civet.

THE analyfis of this fubftance is very little known. According to Neumann, good civet is of a clear yellowifh or brownifh colour, of an uniform confiftence, like butter or honey; it has a very ftrong aroma, which is only agreeable when diluted with other fubftances. It is rarely met with in a genuine ftate; and there is no certain criterion to diftinguifh it by.

It unites eafily with oils, but not with alcohol or water; it however communicates fome of it's aroma to both.

It is ufed as a perfume, and is collected from the inguinal region of the civet cat, which is met with in the Eaft and Weft Indies. The civet is fqueezed out every other day in fummer, and in winter twice a week. The quantity procured at one time is from two fcruples to one drachm or more. Thus collected, it is much purer than that which the animal fheds againft fhrubs or ftones in it's native country. Several of thefe animals have been brought to Holland, and have afforded a confiderable branch of commerce, particularly at Amfterdam.

Neumann's Chemiftry, vol. 2. article Civet.

MUSK.

Mufk.

FOR the beft chemical account of this aromatic fubftance, we are indebted to Neumann, little having been added to it's analyfis fince his time.

Examined by Neumann.

Mufk is either of a dark brown, or rufty reddifh colour; fometimes it is clotted like coagulated blood. To the

touch it is unctuous, and on drying becomes pulverizable. It has a bitterish savour, and it's aroma is peculiarly strong and aromatic, disagreeable if too concentrated, but when largely diluted with other matters, or greatly extended in the atmosphere, it becomes a pleasant perfume. From it's aroma being remarkably diffusive and tenacious, every thing in it's vicinity becomes perfectly infected with it, and retains it a long time. Water extracted two fifths of it, and the distilled water is greatly impregnated with it's aroma and savour; alcohol, took up one third of it, but retained little or nothing of it's aroma. Nitrous and vitriolic acids totally dissolve it, the first destroys the whole of it's aroma, the latter the greater part of it.

Mineral alkali extracts from it the smell of volatile alkali, when these two substances are rubbed together.

Oils have no action upon it. Cast on red hot coals it emits the same fetid smell as urine. On distillation, Neumann obtained the same products as from other animal substances, viz. an empyreumatic oil, a volatile spirit, and salt.

According to Lewis, by impregnating the waters and spirits distilled from odoriferous vegetables with a minute portion of musk, their fragrance is considerably improved, without receiving any of it's own peculiar aroma. Lewis.

According to Fourcroy, it resembles castor in it's chemical properties; it consists of resin, united to a certain quantity of mucilage, bitter extract and salt; it's virtues are stronger than those of castor. Fourcroy.

Musk is extracted from a bag situate near the umbilical region of a ruminating quadruped, resembling the antelope (Moschus Moschifer. Linn.) This bag has no external opening, according to Neumann, like that of the civet cat, and hence the musk is not to be got till after the death of the animal. This chemist informs us, he Origin of musk.

had ſeen the animal alive, and obſerved, that the apartment in which it was kept had a very ſtrong ſmell of this animal aromatic, and that on the white walls againſt which the animal had rubbed itſelf, there was an unctuous matter of the ſame ſmell.

Two ſorts of it.

Two ſorts of muſk are diſtinguiſhed in commerce; the one is encloſed in the bags, the other is extracted, and each of theſe is again ſubdivided according to the countries from which they are brought. Hence ariſes the Tunquin or Eaſt Indian muſk, and the Muſcovy or Perſian muſk. The Tunquin bags have commonly ſmall browniſh hairs upon them, the Perſian large white ones. The former are accounted the beſt; but the difference ſeems to be only in the quantity, and not in the quality, the thinner and leſs having bags containing more in proportion to their weight than the others. From the dearneſs of this drug, it is often adulterated; and there is no criterion to be depended upon to aſcertain it's purity. The only method is to compare it with real ſpecimens.

Neumann's Chemiſtry, by Lewis, article Muſk.— Fourcroy's Elements of Chemiſtry.

COLOURING MATTER.

Before the examination of the colouring matter of different animals, it may be neceſſary to take ſome notice of the action of light upon them.

1. Effects of light upon living animals.

That the human ſkin, on being for ſome time expoſed to the rays of the ſun, changed it's natural whiteneſs to that of brown, vulgarly called freckles or tan, muſt have been known from the earlieſt ages. It equally appears that the difference of colour of the human inhabitants of

the globe depends upon the ſame cauſe, viz. the effect of light upon the rete mucoſum of the ſkin; and ſo univerſal is it's action, that not only the reſt of the animals are ſubjected to it's influence, but it is extended to variegate with different ſhades even the vegetable part of the creation.

Such being the action of light, it is very evident, that the greater the quantity of light, or the more it is concentrated, the greater will be the effects it produces. Thus, in thoſe countries where the rays of the ſun are the moſt intenſe, the darker coloured we ſhould expect to find their inhabitants; and hence that blackneſs peculiar to the negroes and natives of the torrid zone. In ſome parts of Aſia, and in America, and in the ſouthern parts of Europe, we find the colour of the inhabitants varying according to the heat of the climate, from a dark copper colour to a pale tawny; theſe people being leſs expoſed to the light than the negroes, muſt neceſſarily be leſs dark coloured. If we take a view of the northern countries, which are ſtill leſs expoſed to light, we ſhall find their inhabitants nearly white, whilſt the women of theſe laſt countries, and thoſe who have been long confined in the dungeons of priſons, who are the leaſt of all expoſed to the light of the ſun, are ſtill much fairer, and even have a pallid hue. Man.

The ſame cauſe acts on the other animals. Thus we find, that the beaſts of the equatorial countries are uniformly deeper coloured, or, as it is called brighter coloured, than thoſe which inhabit the polar regions, and ſome of the northern animals are dark coloured in ſummer, and white or pale during the winter. Quadrupeds.

The ſame with reſpect to birds, the colours of which are much darker or brighter under the tropics than thoſe of the north. Birds.

Fish and Zoophytes.

Fiſh and Zoophytes, the perceptive inhabitants of the ocean, depend, according to Davy, on ſimilar cauſes for their colours. He has obſerved, that theſe laſt, when expoſed to light, are uniformly brighter coloured than thoſe which have been by any means ſecluded from it; and he ſucceeded in changing the colours of two ſea anemones from a dark red to a pale pink, by ſecluding them from the light.

Parts of animals.

It is the ſame with the parts of animals. Thus in Europeans we find the parts of the body expoſed to light, darker coloured than thoſe that are concealed. Hence the great attention of the ladies, in thoſe countries where fairneſs is accounted an acceſſory to beauty, of covering their necks and faces from the rays of the ſun. The hair on thoſe parts of beaſts likewiſe, which is not expoſed to light, is uniformly paler than on thoſe expoſed to it's influence; and thoſe parts of birds which are not expoſed to light are uniformly pale. Thus the feathers on the bellies of birds are generally white; the back, which is expoſed to light, is almoſt always coloured; and the breaſt, which is partially expoſed in moſt of this tribe, is brighter than the belly, and paler than the back; whilſt thoſe parts, even of the ſame feather, which are expoſed to light, are uniformly brighter coloured than thoſe which are deprived of it's influence. The ſame may be ſaid of fiſh, the parts of which being expoſed to the light, as the back, fins, &c. are always coloured brown, yellow, red, green, blue, &c. in different ſpecies, but the belly, which is deprived of light, is found white in all of them. To extend the ſame obſervations to plants, it is well known, that in order to bleach or whiten them, nothing more is neceſſary than to keep them from the light; hence the bleaching of aſparagus, ſalary, lettuce, &c.

Young animals compared with old.

To the ſame influence may be attributed the paler or lighter colour of young animals, when compared with

old. Thus we are informed that negro children when firſt born are white, and do not become black until after having been a few days expoſed to the light, and this blackneſs is found by obſervation to be conſiderably accelerated by early expoſure to a ſtrong light. It appears alſo that the hair of kittens, puppies, &c. though fitted by nature to become black, is immediately after birth of a browniſh or dark brown colour, which gradually darkens externally as far as it is expoſed to the light, but no farther, for, according to the obſervation of Bancroft, the blackeſt cats and dogs, even in old age, have that part of the hair neareſt the ſkin and moſt ſecluded from light, particularly towards it's root, only of a browniſh black colour, very different from what is ſeen at the ends or points; and Dorthes affirms that moſt of the larvæ of inſects that inhabit the interior cavities of animals, as well as of earth, fruit, wood, &c. are white, and that having detained many of them under tranſparent glaſſes expoſed for ſome time to the light, they loſt by degrees their whiteneſs, and acquired a browniſh colour.

To theſe facts may be added, that Sennebier mentions on the authority of Scheele, that the nereis lacuſtris is red whilſt living in places acceſſible to the ſun's rays, and white in obſcurity; and Dorthes found that the tree frog (rana arborea Lin.) which generally lives in the ſhade, being obliged to ſhift his ſituation into the ſunſhine, changes his colour from a yellowiſh to a very dark green.

Having given ſome account of the action of light upon animate matter, it remains to ſhow it's effects on inanimate matter. And here the ſcene changes, for whilſt it gives intenſity to the colours of living beings, it deprives them of thoſe colours after death. It is thus that in cabinets of natural hiſtory, beaſts, birds, inſects, and even plants, all

2. Effects of light on dead animal

more or lefs lofe their colour, although defended from the air, if they be expofed to the light. This confirms us in the pofition that agents which haften inceffantly new combinations in living beings, only ferve to haften their decompofition, when deprived of life. It is to the action of light alfo that the fading of filk arifes. We are told by Poivre, that yellow filk taken from the cods, and expofed to the rays of the fun, foon becomes perfectly white, and the fame circumftance of natural bleaching happens to ivory and bones after they have become yellow. Thefe effects are fimilar in appearance to thofe which occur to white cotton garments and white lead paint which notorioufly become yellow, if deprived of a free accefs of light for auy length of time, but are again rendered white by reftoring to them their proportion of oxygen to which they owe their whitenefs.

That fubftances imbibe light has been long obferved; for Beccaria informs us, that bones, teeth, bezoars, nephritic and urinary calculi, and egg fhells which had been expofed to the fun, gave light in the dark.

Manner of action of light. There have been feveral opinions with refpect to the manner in which the rays of light act upon animal fubftances fo as to give rife to the facts already mentioned. Berthollet. According to Berthollet, thefe changes are produced in animals by a fpecies of combuftion, which from it's great flownefs is not able to effect a decompofition of the parts fo as to amount to their deftruction, but only to a deftruction of the hydrogen, which as it combines more eafily, and at a lower temperature than charcoal does, leaves the charcoal predominant, fo that the natural colour of charcoal is more or lefs blended with that which before exifted, and as the light of the fun confiderably accelerates the deftruction of colours; he concludes, that it ought, if his theory be well founded, to favour the combination of oxygen and the combuftion thereby produced.

Dr. Bancroft does not coincide with the opinion of Berthollet; on giving his ideas on this subject, he first attempts to prove, that light wil lunite with oxygenand separate it from it's compounds; hence the revivification of gold, silver, &c. from their oxyds by the contact of light, as Scheele has proved, which, according to Berthollet, is produced by the light separating the oxygen in the form of pure air. Hence a bottle filled with oxygenated muriatic acid, exposed to the light, lets go it's oxygen, and becomes common muriatic acid, whilst, if wrapped in black paper and exposed to the sun, it suffers no change; and if heated in the dark, flies off in the form of oxygenated muriatic acid gas without any separation of it's oxygen. Bancroft.

Light having therefore this effect on oxygen, it accounts for it's action respecting the colours of different substances. Thus the nitrous acid, by being deprived more or less of it's oxygen by light, and by letting the azot predominate in a greater or less degree, assumes a variety of colours, as yellow, orange, aurora colour, red; and according to Keir, an orange coloured nitrous acid by long keeping became green, and afterwards of a deep blue; hence we have an example of all the various colours produced by the two species of air that compose our atmosphere, when mixed in certain proportions. This mode of reasoning, Bancroft applies to animal substances. The only thing he thinks, however, to be ascertained on this point is, whether the colours which accompany or require the application of light, result directly from a combination of it with the coloured substance, or indirectly from it's particular action in occasioning a separation of airs or their bases (and particularly of the oxygen) or by favouring a combination thereof with the coloured matter. Almost all animal and vegetable substances are found to emit light in certain stages of putrefaction or

decompofition, and therefore it may be prefumed to have been previoufly combined with fome of their parts; but how it acts, or whether it acts at all immediately in producing the colours of any object, feems yet uncertain, though we know it does contribute greatly to the production or change of colours in a number of animal and other fubftances, in fome cafes by combining with the bafis of vital air (oxygen) and feparating, by rendering it elaftic, and in others, by promoting the action or union thereof upon or with particular fubftances; but it feems difficult to afcertain the particular affinities, by which fometimes the one, and fometimes the other of thefe effects are produced. Thus, a folution of filver in the nitric acid changes colour by the action of light, and becomes black, which arifes from the feparation of a certain portion of oxygen; the fame is effected by the application of all inflammable bodies, and in this manner negro children which are white, immediately after birth become black, after having been expofed to the light a few days. With refpect to thofe inftances of the nereis lacuftris, of the larvæ of infects, and of the tree frog, it does not appear certain to Dr. Bancroft whether the light produces the changes of colour by caufing an abftraction or an addition of oxygen, but from what is known of it's effects in cafes apparently fimilar, he thinks it acts in one or other of thofe ways.

He thinks it does not appear reafonable to conclude, that light contributes to thefe effects on the colours of animal as well as of other bodies, otherwife than by it's affinity with oxygen, which affinity under fome circumftances, and with the aid of perhaps other unknown affinities, fometimes feparates and renders the oxygen elaftic by uniting with it, and at other times occafions the combination of an increafed portion thereof, with the coloured fubftance. He thinks that Berthollet in his theory

has gone further than is warrantable by facts. He thinks the colour of each particular fubftance evidently depends on it's peculiar conftitution, producing in it a particular affinity or attraction for certain rays of light, and a difpofition to tranfmit or reflect certain other rays; and in this refpect that it may doubtlefs fuffer very confiderable changes from the action or combination of oxygen, without any effects fimilar to thofe of combuftion.

The opinion of Davy nearly refembles that of Dr. Bancroft. He ftates, that the cuticle, which is of the fame colour, and equally pellucid in the different fpecies of mankind, appears to contain no oxygen or light, and that it is moft probably compofed of carbon, hydrogen and nitrogen; that the rete mucofum is probably compofed of carbon, oxygen, hydrogen and nitrogen; that the comparative quantities of carbon and oxygen in it appear to occafion the differences of it's colours, that thefe quantities depend on the quantity of oxygen attracted from it by light; thus light acting upon the rete mucofum of the African is continually fubtracting oxygen, the principle to which it's whitenefs is owing, and when the oxygen is fubtracted, the carbon becomes the predominant principle; hence the blacknefs of the negro, and the lefs the inhabitants of a country are expofed to light, the more oxygen their rete mucofum will contain, and the more whitenefs; hence the fair people of the north contain in their rete mucofum it's full proportion of oxygen. It appears that a fubtraction of oxygen from the rete mucofum, by any means, uniformly blackens it; thus the application of fulphure of potafh, according to Davy's experiments, blackens the fkin almoft inftantly. On the contrary, by combining with oxygen the rete mucofum is uniformly whitened, thus Dr. Beddoes whitened the fingers of a negro by means of muriatic phofoxyd (from φως light, and οξυς acid) which appears capable of Davy.

giving out a ſmall portion of oxygen, and of ſtill retaining all the light entering into it's compoſition. According to this author, the different colours of the different parts of the organic matter of the body depend chiefly on the light and oxygen entering into their compoſition. Thus the red muſcles are phoſoxydated compounds, which probably owe their colour to their light, whilſt from the white colour of the nerves, and their office of conducting and being excited into ſenſible action by condenſed light, we may conclude, that no light enters their compoſition.

To conclude, Davy is of opinion, that though the differences of the colour of the ſkin of different nations muſt have originally depended entirely on the chemical influence of light, yet when once theſe colours are produced, their changes are in ſome meaſure dependant on the mind; that when certain colours are conſidered as beautiful, the generating imagination makes them hereditary, and the chemical changes of the influence of light are more ſlowly produced; hence Europeans, though expoſed to light in the African countries, do not become black but in a great length of time, and negroes, though deprived of light, their accuſtomed oxygen attractor, are not blanched for many generations.

Of light emitted by living animals, or their dead parts.

Since light is found to have ſuch an influence on animals and their parts, and that it appears to be imbibed by them, it may be ſuppoſed, that on certain occaſions an emiſſion of that luminous body muſt be the conſequence, and this had not only been long ago obſerved with reſpect to living animals, ſuch as ſome kinds of inſects and worms, but even common fleſh had been obſerved to diſplay that appearance, as is evident from the accounts of Boyle, Fabricius ab Aquapendente, Bartolin, Dr. Beale, &c. but for a more minute and detailed inveſtigation of this ſubject, we are indebted to Spallanzani,

Carradori, Brugnatelli and Dr. Hulme; the laſt, in particular, has greatly extended our knowledge of the properties of this luminous matter by a number of curious and intereſting experiments.

Theſe philoſophers, as well as others, however, differ with reſpect to the origin of this light, which is emitted not only from living animals, but alſo from parts of them when dead; on one part, it is ſaid, that it is nothing but phoſphorus which is undergoing a ſlow combuſtion; on the other, it is aſſerted, that the rays of light being abſorbed, are concentrated, and afterwards emitted according to circumſtances. Perhaps, it is impoſſible at preſent to determine which of theſe opinions is the truth, a further inveſtigation being neceſſary before a ſatisfactory diviſion can be made. Opinions of it's origin.

Foſter of Gottingen has obſerved, that the phoſphoric part of the glow-worm is liquid, and if this animal be preſſed between the fingers, the phoſphoreſcence remains on them. Chaptal ſuppoſes, that as phoſphorus is ſoluble in oils, particularly in volatile ones, which are then luminous, this combination of phoſphorus and oil is natural in the glow-worm (Lampyris ſplendidula). According to Carradori, the phoſphoric part of the Italian glow-worm (Lampyris Italica) does not extend further than the laſt rings of the belly; it is there encloſed in an envelop or bag, compoſed of a membrane, one portion of which forms the ſuperior, the other the inferior part of the belly, and which are united together. Behind this receptacle the phoſphorus is found, reſembling a paſte, having the odour of garlic, and only a little ſavour: the phoſphorie matter is ſqueezed out on the leaſt preſſure, but when ſeparated from the body, it loſes it's ſplendour in a very ſhort time, and is converted into a white, dry matter. Light of glow-worms.

Spallanzani has made ſome experiments to determine the difference between the light emitted from phoſphorus Examined by Spallanzani.

and that of glow-worms, &c. He made them in oppofition to thofe of Goettling, and with his eudiometer, which is the fame as that defcribed for the combuftion of phofphorus, in the Encyclop. Dict. It confifts of a glafs tube, the lower end of which is open, and plunged into water or mercury. The upper part is clofed, and bent horizontally, the phofphorus, or other fhining matter, is put into that part about to be expofed to the action of the gas in the tube, and the diminution of the volume of this gas fhows the quantity that unites with the phofphoric matter.

He firft tried the action of different gafes upon phofphorus itfelf, in their pure ftate, and found, that azot carbonic acid, and hydrogen gafes introduced fingly, one after the other, into the eudiometer, excited no light from the phofphorus. In very pure oxygen gas it did not begin to burn and produce light, till at 22° of Reaumur. If the azot gas was mixed with it, light was produced at 12°, and by the mixture of hydrogen gas at 5°. Spallanzani, however, does not conclude it is from the gafes that the light originates, for oxygen gas alone produces it, but a high temperature is neceffary, on the contrary, the other gafes when alone, cannot produce it at any temperature. Hence it is the oxygen gas that is the immediate caufe of the combuftion, and of the light; and he thinks it can only be faid, that the other gafes difpofe the oxygen and phofphorus to a more ready combuftion, and at a lower temperature. The more oxygen in the mixture, the more lively the light, and the more of the other gafes, the lefs is the occafion for raifing the temperature; hence the oxygen is the caufe of the production of light, and the other gafes only make up for that temperature.

Having thus examined phofphorus, he directed his attention to what he calls other phofphoric fubftances, fuch as glow-worms, putrid fifh, fhining wood, &c. and thefe

presented to him the same phenomena as common phosphorus, as to the light. He found, that plunged into hydrogen or azot gases, they lose, by degrees, their phosphorescence, and sooner in carbonic acid gas, that they shine again on admitting common air, and become brilliant in oxygen gas. Water does not deprive them of their phosphorescence. The same was observed after their death, and in the luminous parts separated from their bodies.

He found the light of glow-worms to be strengthened by shaking, by the will of the animal, and this momentaneous increase of light was accompanied by a vibrating motion in the phosphoric part of the animal; it appeared to him to be made at the moment of breathing, and may be produced by pricking the animal. Exposed to a refrigerating mixture, the glow worm loses it's phosphorescence at 7° and becomes hard from cold, but withdrawn and placed in a mild temperature, it becomes luminous again. It also loses it's light on exsiccation, and receives it again on being softened with water. Spallanzani concludes, that the light of these phosphoric bodies arises from a slow combustion of the hydrogen and the carbonated hydrogen gases, of which animal and vegetable substances are in part composed.

Fourcroy explains the origin of the light of phosphorescent bodies, from the disengagement of the real phosphorus itself dissolved in the hydrogen and carbonic acid gases. Fourcroy.

Although it is the opinion of Spallanzani and others, of combustion being the cause of light in the phosphorescent bodies, there are several celebrated chemists who entertain a different opinion, and that light is only extricated.

Brugnatelli calls that light which bodies have the power of absorbing, during their exposition to the rays of the sun, Brugnatelli.

aggregate sensible light. He affirms, that the eyes of the hyena and cat possess, this power even to the point of enlightening objects, and in short, all animals called phosphoric shine from the disengagement of the aggregate light. He, however, observes, that those bodies which emit light, or become phosphorescent on being heated to a certain degree, for instance, as feathers, wool well dried powder of sugar of milk, fat and sweat, &c. when lightly passed upon a hot iron that is not red, disengage their light *by combining with caloric*; hence light chemically combined only separates from these from the effect of *a greater attraction.*

Carradori. But of all the opponents to the doctrine of phosphorescent light being produced by combustion, perhaps Carradori may be looked upon as the most formidable. His observations are particularly directed against those of Spallanzani.

Carradori found, that the phosphorescent light of glow-worms (lucciolonì & lucciole) is suddenly extinguished if plunged into alcohol or vinegar, but continues to shine under oil, as well as in water or air; he has seen the glow-worms as well as the phosphorescent part detached from them, continue to shine under oil for hours together. If therefore these two kinds of glow-worms, which are of different species, and likewise phosphoric wood, continue to shine under oil, the light cannot proceed from a slow combustion, as Spallanzani pretends, since there is no air in oil to entertain it; and if the glow-worm shines under water, because, as Spallanzani maintains, the oxygen gas, which is one of the principles of the water, swells the combustion, why, he asks, does not the phosphorus of kunckel shine under water? Carradori has likewise seen a glow-worm that continued to shine perfectly in vacuo. He affirms, that the light of these insects is peculiar and innate, and as several other animals have the power of

accumulating the electric fluid, and of keeping it condenſed in peculiar organs, to emit and expand it afterward at will, ſo may the glow worms have the faculty of retaining, in a ſtate of condenſation, the fluid which conſtitutes light; he thinks that they may have the power even of extracting the light which enters into the compoſition of their aliments, and of tranſmitting it into the reſervoir in their abdomen; or it is poſſible they may have the power of extracting the luminous fluid from the air, as other animals do heat from it by a chemical proceſs; and the new doctrine of Goettling on combined light, which has been ſimplified by Brugnatelli, renders this opinion, he thinks, very probable.

He is of opinion, that the obſervations made by Forſter, that glow-worms emit a ſtronger and more lively light in oxygen gas, than in common air, does not depend on combuſtion, and it's being rapidly excited by the reſpiration of this gas, but ariſes from a more agreeable and lively exiſtence they feel, for the ſame happens in other circumſtances. Thus when they fly freely without any interruption, their light is regular and beautiful; but once in our power, they either emit light irregularly or not at all. On being diſturbed, they emit a frequent light, and this appears to be a mark of reſentment; when placed upon their backs, they ſhine almoſt without interruption, by making continual efforts to extricate themſelves. During the day, they muſt be tormented to ſhine, a proof of it's being the time of their repoſe. They can ſhine at will in every point of their belly, a proof of their being able to move any part of it independent of the other, and they render this phoſphoreſcence more or leſs lively, and emit it as long as they pleaſe. On being plunged into warm and cold water, alternately, they ſhine with vivacity in the firſt, and extinguiſh their light in the laſt, another proof of an alternately agreeable and diſagreeable

fenfation, giving rife to or diminifhing it; in hot water, the light difappearsby degrees. Hence their light does not depend on external caufes, but on their will. He likewife found, that from his experiments on them, the phofphoric matter undergoes no foluble action except from water.

This faculty of fhining is not deftroyed, according to Carradori, by incifion, or tearing open the belly; he faw a part of one, almoft extinguifhed, become fuddenly luminous for a few feconds, and then infenfibly go out; and fometimes he has feen a fimilar portion cut out, pafs fuddenly from the moft beautiful brilliancy to a total extinction, and reaffume in a moment it's priftine brightnefs. He attributes this to a remnant of irritability, or more probably to the ftimulus of the air, a mechanical irritation producing the fame. A flight compreffion takes away their faculty of ceafing to fhine. A piece of the phofphoric belly put into oil fhone but faintly, and was foon extinguifhed. Exficcation he found to fufpend the light, whilft foftening in water made it reappear again. Reaumur, Beccari, and Spallanzani, obferved the fame with refpect to the medufa, &c.

Carradori, therefore, differs from Spallanzani, who looks upon the caufe of phofphorefcence to be a flow combuftion; and from Goettling, who attributes it to the ficcation of the azot gas; and concludes, that it arifes from a diffipation of aggregate light. He fupports this againft the philofopher of Pavia, upon the experiments of Beckerheim, who has demonftrated that phofphoric infects fhine when plunged in gafes improper for combuftion; and upon thofe of Beccari, Brugnatelli, and Dufay, who have proved that light may combine and accumulate in bodies, in a greater or lefs quantity, according to their capacity for it.

Dr. Hulme's experiments on light itfelf.

Dr. Hulme diftinguifhes this light emitted by various bodies from all kinds of artificial phofphori, by calling it

ſpontaneous light; and by it's adhering to bodies with ſome degree of permanency, from that tranſient ſort of light obſerved in electricity, in meteors, and in other lucid emanations.

The ſubſtances from which it is emitted are principally living and dead marine animals; of the firſt, are the ſhell-fiſh, called pholæ, the meduſa phoſphorea, and other molluſcæ; of the ſecond, marine fiſhes in general, when dead, abound with it. In the claſs of inſects, it is well known, many emit light very copiouſly, particularly ſeveral ſpecies of fulgora or lantern fly, of lampyris, or glow-worm, as obſerved before; alſo the ſcolopendra electrica, and the cancer fulgens.

Boyle obtained light for his uſe from the whiting; but Dr. Hume procured it for his experiments, chiefly from the herring and mackerel. His laboratory was a dark wine vault, the heat of which varied throughout the year from about 40° to 64° of Fahrenheit. The weight he uſed was troy; the liquid meaſure, wine; and the water, pure ſpring, and always cold, except otherwiſe expreſſed.

1ſt. From the experiments of this phyſician on herrings and mackerel, which he had previouſly gutted, ſcaled and hung in his laboratory; it appears that light begins to be emitted by them before any ſigns of putrefaction appear, and that as ſoon as a great degree of putreſcence has taken place, the luminous property of marine fiſhes is deſtroyed and the light extinguiſhed; which corroborates the obſervations of preceding authors on the luminous appearance of the fleſh of quadrupeds, all of whom ſay it was freſh; whenever, therefore, Dr. Hulme was deſirous of obtaining a plentiful ſupply of light from theſe marine animals for his experiments, he always procured the fatteſt he was able. This proves that the common opinion, of the quantity of light emitted by animal ſubſtances being in proportion to the degree of putrefaction,

is erroneous, and that on the contrary, the greater the putrefcence, the lefs is the quantity of light emitted.

2. He found that this light is a conftituent principle of thefe bodies, that it may be feparated from them by a peculiar procefs, and retained and rendered permanent for fome time, for it feems to be incorporated with their whole fubftance, and to form a part of them in the fame manner as their other conftituent principles.

He put pieces of frefh herring, weighing about four drachms each, in aqueous folutions of different quantities of Epfom and fea falts, and in fea water; the phial which contained them having a wide mouth, and he found, on the fecond or third night, they became luminous, which light gradually difappeared on the fixth or feventh. Similar experiments were alfo made with the roe of herrings, the flefh and roe of mackerel, and with the tadpole, the flefh and roe remaining quite frefh and fweet, which proves that the menftruum had extracted their light. The foft roe abounds more with light than the flefh, whilft the hard roe is lefs luminous than the foft; he found the moft luminous ftate of the foft roe to be about the third or fourth night, when it fometimes fhone fo very fplendidly as to appear like a complete body of light: they were laid upon plates in the laboratory. Dr. Hulme, therefore, concludes, that this lightforms one of their conftituent principles, that it is feparated by the menftruum employed, in the fame way as the principles of any other body are feparated by the menftruum fitted to decompofe it; and as the light appears in the internal part on expofure after being cut, he thinks it fhows, that it is not partial, but wholly incorporated with every part of their fubftance, forming a part thereof, like any other conftituent principle. Hence it feems probable, that light is the firft conftituent principle that efcapes after the death of marine fifhes, as it appears foon after,

and the flesh and roes infused in the saline menstruums continued to emit light for several days without undergoing any apparent putrefactive change. His experiments also render it probable, that no offensive putrefaction takes place in the sea after the death of such myriads of animals as daily perish in the vast ocean, which is quite contrary to what happens on land, and that the flesh of marine animals remains pretty sweet for some time.

3. Dr. Hulme found, that some bodies have a power of extinguishing this spontaneous light when it is applied to them; for the luminous matter of the herring and mackerel was quickly extinguished when mixed with, 1. Water alone; 2. Water impregnated with quicklime, carbonic acid, and hepatic gases; 3. Fermented liquors, ardent spirits; 4. Vegetable acids and mineral, both concentrated and diluted; 5. Fixed and volatile alkalis dissolved in water; 6. Neutral salts, viz. *saturated* solutions of Epsom and common salt, and sal ammoniac; 7. Infusion of chamomile flowers, long pepper, and camphor, made with boiling water, but not used till quite cool; 8 Pure honey, alone.

4. He found, that other substances have the power of preserving spontaneous light some time, when it is applied to them, for some of the luminous matter scraped from the herring, and mixed with a solution of two drachms of Epsom salt in two ounces of cold pump water, being well shaken in the phial, the whole liquid became richly impregnated with light, and continued shining for above 24 hours. The same took place in a solution of Glauber's salt. Mackarel-light afforded the same phenomenon in the aqueous solutions of Rochelle salt, or tartarized natron, common salt, sea water, aqueous solution of honey; and herring-light in the solutions of soda phosphorata, saltpetre, refined sugar, and soft brown sugar; the degree of illumination depending on the quantity of lucific mat-

ter applied; in general, however, as much as can be ſcraped off by the blunt point of a moderate ſized knife, at a few times, will be ſufficient when aſſiſted by a ſtrong agitation of the phial. By ſuch means the whole liquid is rendered moſt brilliantly luminous; and we are enabled to impregnate the water with light, which light is ſo extended on it's ſurface, and combined in ſuch a manner as to become exceedingly convenient and uſeful for various other experiments.

5. He found, that when ſpontaneous light is extinguiſhed by ſome bodies, it is not loſt, but may be again revived in it's former ſplendour. Some ſhining matter from the mackerel was immediately extinguiſhed in a ſolution of ſeven drachms of Epſom ſalt in one ounce of water; but in a ſolution of two drachms it was luminous, and more ſo in one drachm; obſerving, therefore, the extinction of it in the more ſaturated ſolutions, while the diluted were luminous, he endeavoured to find what became of the extinguiſhed light, and whether it might not be revived by dilution, and found, that on diluting the ſolution of ſeven drachms with ſix ounces of water, light immediately burſt out of darkneſs, and the whole liquid became beautifully luminous, which remained above 48 hours, *i. e.* as long as other light does in general, which has never been extinguiſhed; and by reverſing the experiment, extinction is the conſequence. In one inſtance the ſame light, by a repetition, underwent ten extinctions.

Dr. Hume found, that if the illuminated liquid be uncommonly brilliant, it may ſometimes require more ſalt to extinguiſh the light than what he has ſpecified, in which caſe, the meaſure of water for dilution muſt be always calculated in exact proportion to the weight of the ſalt employed.

6. Spontaneous light is rendered more vivid by motion, for ſome illuminated liquor which had become

quite dark, on drawing through it a finger or rod, it was followed by a luminous line, and on moving another quantity gently, that had loſt it's luminous quality, except a little glimmer floating at the top, the light diffuſed itſelf gradually through the whole liquid; on agitation, the lucidneſs was much increaſed, and the briſker the motion, the more vivid was the illumination.

7. Spontaneous light is not accompanied with any degree of ſenſible heat to be diſcovered by the thermometer, for a luminous and a nonluminous herring being in the ſame temperature, afforded no difference to the thermometer, the bulb of which was applied to them, nor did the mercury riſe when it was placed either upon a luminous ſoft roe, or upon a lucid mackerel.

8. Dr. Hulme tried the effect of cold on this ſpontaneous light. He placed gallipots containing pieces of ſoft roe of herring, and of herring itſelf, all luminous, in a frigorific mixture of ſnow and ſea ſalt, and the light was extinguiſhed in half an hour, and the bodies frozen. On removing the gallipots into a veſſel of cold water, they recovered their former luminous ſtate as they thawed, and ſhined for three ſucceeding nights. The ſame took place with ſome liquid impregnated with light, and placed in a cold mixture. The light of the glowworm was affected in the ſame manner; hence cold extinguiſhes ſpontaneous light in a temporary way, but not durably, ſince a moderate temperature revives it again.

9. He tried the effects of heat on ſpontaneous light. One ſide of a luminous fiſh expoſed to the fire ſo as to heat it ſtrongly, was quite dark on that ſide in the laboratory, whilſt the other remained luminous; and the light did not reappear. A whole herring, very ſplendid, being thrown into boiling water, had it's light immediately extinguiſhed, nor did it afterwards revive. Dead ſhining glowworms being put into a phial of water at 58°, and ſunk in

boiling water, their light became more vivid; the glowing property was alfo augmented at 114°. Heat alfo, obtained from folid bodies by friction, increafed it; thus two living glowworms perfectly dark, put into a phial that was rubbed brifkly till it became pretty warm, generally difplayed a fine light. The fame took place on the light of a dead glowworm.

On pouring fome boiling water on a dead luminous glowworm, it was immediately extinguifhed, and did not revive. Dr. Hulme found, that any of the faline folutions mentioned at 4, on being impregnated with light and left fome time at reft, were rendered more lucid by a *moderate* degree of heat; but their light was extinguifhed by a *great* degree of heat. It appears that this fpecies of light, united with water, begins to be extinguifhed at from 96° to 100°, and that the method of adding the hot water by degrees, and in fmall quantities, is very elegant, and fhows how much heat is requifite to extinguifh the light; but to prevent the poffibility of any light being renewed after an experiment of this kind, requires a much greater heat than that of 100°.

Dr. Hulme found that if much heat be applied to the bottom of a tube filled with illuminated liquid that has been fome time at reft, the light will defcend in luminous ftreams from the top of the tube to the bottom, and be gradually extinguifhed. He filled a tube nine inches long, and 1 $\frac{1}{10}$ of an inch diameter, which was clofed at one end, with fome very luminous liquid over night; and procured a gallipot three inches and a half deep, and three and a half wide, holding 12 oz. of boiling water, the next evening; the tube which had been placed in the laboratory, and the light of which had afcended plentifully, taking the circular form of the tube, and forming a very lucid ring at the top of the fluid, had it's bottom immerfed in the boiling water in the gallipot, when the light ap-

peared to defcend in about the fpace of half a minute in ftreams to the bottom, illuminating the whole fluid during it's defcent in a very beautiful manner, and then was gradually extinguifhed. This extinction began at the top and ended at the bottom. The moft eligible folutions for this kind of experiment are made of Epfom and Glauber's falts, fea water and fal ammoniac; and the experimentalift, before he views the defcent of the light in the tube, fhould always remain in the dark for fome little time, to get rid of all the extraneous light adhering to the organs of vifion, and to accuftom the eye to darknefs.

10. The effects of the human body and of the animal fluids upon fpontaneous light, Dr. Hulme found to be as follows: 1. *The living body.* On touching the luminous part of fifhes, the light adhered to the fingers and different parts of the hands; it remained very lucid fome time and then gradually difappeared; but on being applied to pieces of wood, ftone, &c. of the fame temperature as the laboratory, it continued luminous upon them for many hours. 2. *Blood.* Herring light mixed with craffamentum or red coagulated part of the blood, and well ftirred, became flightly luminous, but not of long duration; nearly the fame happened on mixing the lucid matter with recent craffamentum of pleuritic and rheumatic people; but with black and offenfive craffamentum the light feemed to be more quickly extinguifhed. There was a curious circumftance, that on mixing fifh light with putrefcent bloody ferum, it would not incorporate, but was ejected in globules like quickfilver, and afterward adhered to the fide in form of a lucid ring. Mixed with pure healthy ferum, the herring light was foon highly illuminated. 3. *Urine.* Mackerel light being ftrongly agitated with frefh urine, a glimpfe of light was retained at firft, and then gradually extinguifhed; but ftale and

pungent urine had a ſtill more extinguiſhing effect. 5. *Milk.* Mackerel light incorporated by ſtrong agitation with freſh cows milk, became highly luminous and continued ſhining above 24 hours. Freſh cream alſo retained ſome light, though (perhaps owing to it's thickneſs) it was not ſo viſible as with milk. When, however, milk or cream turns ſour, it contracts a very extinguiſhing property, as it puts it out immediately.

COLOURING MATTER.

Colouring matter.

It appears, on treating of the action of light on animals, that it has a great influence on the production of their colours, and that light itſelf when imbibed by bodies, may become the ſubject of curious inquiries; it now remains to give ſome account of the nature of colouring matter, and of the chemical action which different reagents have upon it, for the purpoſes of dying. Upon taking a general view of the animal creation, we find there is a great variety of colours, not only in different animals, but even in the parts of the ſame animal. Thus, in man, and all quadrupeds in particular, blood is from a bright vermilion colour to a dark purple; in inſects it is white; the fleſh of the former is univerſally red; that of fiſh generally of a more or leſs pale colour. The nerves of an animal are of an opake pearl, whilſt the tendons ſhine like ſilver, and the brain, the liver and the lungs have each their peculiar colour; the ſame may be ſaid of the other parts. In ſome animals, likewiſe, it appears that colours only pervade the ſurface and cannot be collected, or if they are, the colouring tinge is ſlight and evaneſcent, and ſoon diſſipates; in other animals, or their parts, the colour is as it were ſo concentrated as not only to be ca-

pable of being extracted by different menstrua, but so stable as to be communicated to other substances to which a colour is given equally firm and durable. This matter, the colour of which can be so communicated, may be called the *colouring matter* of animals, and it is from this kingdom that the most rich and exquisitely beautiful colours are to be extracted, although they are very few in number.

With respect to the origin of colour, little or nothing is known. According to the principles of optics, the colouring parts of an animal (as well as of the other kingdoms) may be said to be those parts which possess or acquire a power of acting on the rays of light, so as either to absorb them all, and produce the sensation of black, as the ink of the cuttle fish, or only to absorb particular rays and transmit or reflect the others, and thereby produce the perception of that particular colour which belongs to the ray so transmitted or reflected.

Some have attributed the power of acting on the rays of light to phlogiston, others to the presence of iron, but the candid and impartial judge must acknowledge the want of a satisfactory explanation.

There is great reason to believe that it depends upon the proportion of the component parts of bodies, more than upon the particular form or shade of those ultimate parts; and the prevailing opinion is that the most essential circumstance in the production of colour depends on the absence or the different quantity of oxygen, which the coloured matter retains in it's composition. A comparative view with the different oxyds of the metals, the colours of which appear to depend on the different proportion of oxygen they contain, may afford strong arguments in it's favour; but in animal substances, as the oxygen cannot easily be separated without decomposing the other component parts, it is much more difficult to determine whether the colours depend upon the different pro-

portions of component parts, and in what manner they are affected by the abſence or preſence of the oxygen. A further inveſtigation is neceſſary to clear away all the doubts on this intereſting ſubject. In the mean time we muſt reſt ſatisfied with the explanations of the three ingenious chemiſts before mentioned.

Independent, however, of the form and figure of the particles of bodies, the opinion of ſir Iſaac Newton (who aſſerted that *all coloured matter reflects the rays of light*, ſome bodies *reflecting* the more refrangible, others the leſs refrangible rays, more copiouſly, and which he affirmed was the only true reaſon of theſe colours) has been called in queſtion, and in the progreſs of inquiry another theory has been attempted, which Delaval ſupports by numerous experiments. They were firſt made on tranſparent coloured ſubſtances, as being of the ſimpleſt kind, conſiſting only of the colouring particles united with and diffuſed throughout tranſparent media, ſuch as ſpirit of wine, water, &c. From the examination of ſuch tinged media he has been enabled to diſcover ſeveral properties of coloured matter, very different from what has hitherto been ſuppoſed to prevail: for inſtance, Delaval affirms, from his experiments, that in tranſparent coloured ſubſtances, *the colouring matter does not reflect any light*, and when by intercepting the light which is tranſmitted, it is prevented from paſſing through ſuch ſubſtances, they do not vary from their former colour to any other colour, but become entirely *black*.

Experiments of Delaval.

For the purpoſe of obſerving the manner in which tranſparent coloured bodies act upon the rays of light, he procured ſmall vials of flint-glaſs, of a parallelopiped form. He covered the bottom and three of the ſides of each of theſe phials with a black varniſh, the cylindrical neck and the anterior ſide, except at it's edges, were left uncovered; hence no light could be admitted, except through

the neck and anterior fide of them. The uncovered fide fhould be placed oppofite the window, but in fuch a direction as to form a right angle with it. He conftantly found that the liquor in the neck exhibited it's colour diftinctly and vividly, whilft that in the body of the vials, viewed through the uncovered fide, exhibited no colour, but was black; and as to the expreffions *reflected light* and *tranfmitted light*, as tranfparent coloured bodies are not endued with any *reflective* power, the word *reflected* cannot be properly applied to the light which falls on them; he has therefore fubftituted the words *incident light*, inftead of *reflected light*.

TABLE of tranfparent coloured liquors viewed by tranfmitted and by incident light, from the animal kingdom.

	By tranfmitted light.	By incident light.
1. Cochineal infufed in diftilled water	red.	black.
2. ———————— in fpirit of wine	red.	black.
3. Kermes infufed in diftilled water	yellow.	black.
4. ——————— in fpirit of wine	yellow.	black.
5. Ox gall diluted with diftilled water	yellow.	black.
6. Blood with fpirit of fal ammoniac	red.	black.

The few experiments juft cited are thofe which Delaval made on animal fubftances, and are extracted from a numerous collection of others made in the three kingdoms. The author informs us, that thefe fhow, that tranfparent coloured liquors do not, as before afferted, yield any colour by reflection, but by tranfmiffion only. If thefe liquors are fpread thin on any white ground, they appear of the fame colours which they exhibited when viewed in the necks of the vials, as the light reflected from the white ground is, in this cafe, tranfmitted through

the coloured medium; but when they are ſpread upon a black ground, they afford no colour; but the black ground ſhould not be a poliſhed body, as the light reflected by it would be tranſmitted through this medium on it's ſurface, and be tinged by paſſing through it.

He found alſo that opake bodies do not exhibit their colours by reflecting the rays of light: he affirms this to be a general law; and as animal ſubſtances do not afford any great variety of coloured products, yet, ſince in thoſe which do exhibit colours, the colouring particles are endued with the ſame properties which prevail in vegetables, they muſt be regulated by the ſame laws. In vegetables, on depriving them of their colouring matter, there remained a ſolid white earthy ſubſtance, which is the only part of them endued with a reflective power; he aſſerts, their colours are produced by the light reflected from this white matter, and tranſmitted from it through the coloured coat or covering which is formed on it's ſurface by the colouring particles; and that when the colouring matter is diſcharged, the ſolid earthy ſubſtance is expoſed to view, and diſplays that *whiteneſs* which is it's diſtinguiſhing character. In like manner fleſh, which conſiſts of fibrous veſſels containing blood, is perfectly *white*, when diveſted of the blood by ablution. The membranes, ſinews, bones, and other ſolids are white, and when freed from their aqueous and volatile parts, they are a mere white earth, unalterable by fire, and incapable of imparting to glaſs an opake whiteneſs.

From the experiments with blood abovementioned in the vials, and from the above conſiderations, it appears to Delaval, that the florid colour of the fleſh ariſes from the light which is *reflected* from the *white* fibrous ſubſtance, and tranſmitted back through the red tranſparent covering, which the blood forms on every part of it.

The blood whilſt recently drawn does not aſſume the

appearance common to tranſparent coloured liquors, for ſuch liquors, when too maſſy to tranſmit light from their farther ſurfaces, are black. But blood recently drawn yields a red colour, in whatſoever maſſes it is diſpoſed. The colour thus exhibited ariſes from a white matter diffuſed throughout the blood. This white matter is eaſily ſeparable from the red part of the cruor. This may be performed by dividing the cruor after it is coagulated into thin pieces, upon which a ſufficient quantity of water muſt be poured. The cruor communicates a red tinge to the water, which ſhould be changed every day; after a few days, the water no longer receives any tinge, and the remaining maſſes of the cruor are by theſe means rendered perfectly white. Thus it appears, that not only the fleſh, but alſo the blood itſelf, are white ſubſtances tinged with red particles.

The red colour which the ſhells of lobſters aſſume after they are boiled, is a mere ſuperficial covering, ſpread over the white calcareous earth of which the ſhells are formed, and may be eaſily removed by ſcraping or filing the ſurface. Before this ſuperficial covering is attenuated by the heat, it is much denſer, ſo that in ſome parts of the ſhells it appears black, as it is too denſe to admit the paſſage of the light to the white ſubſtance of the ſhell, and back again. But where this tranſparent blue colour is ſpread thinner and rarer, the light reflected from the white ſubſtance of the ſhell is tranſmitted back through the blue film, and yields a light blue colour. The colour of the ſhells of ſeveral ſpecies of eggs is alſo merely ſuperficial, and may be ſcraped off, leaving the white earth of the ſhell expoſed to view.

Feathers in like manner, according to Delaval, owe their colour to thin layers of coloured matter, covering the white ſubſtance, of which they are principally formed. He ſcraped off the ſuperficial colour from ſuch parts of

vividly coloured feathers as were folid enough to admit of that operation, and by this means feparated the coloured layers from the white ground, on which they had been naturally fpread. The furfaces of the lateral fibres of feathers cannot be thus feparated on account of their minutenefs. But as they appear, when viewed with a microfcope, nearly to refemble in their form the feathers themfelves, it feems probable, that their colours arife from a fimilar matter and conformation in the fmaller fibres, as in the groffer parts of the feathers.

The colours of all animal fubftances, which have fallen under his obfervation, appear to him to be effected in the manner defcribed. In all the inftances, the colours of the bodies are produced by the light reflected from a white fubftance, and tranfmitted back from it through a tranfparent coloured covering. The colouring particles were extracted from fuch of the bodies as were capable of yielding them to any proper folvents, and in their ftate of folution, as well as when condenfed into a folid confiftence, they were conftantly found to poffefs a power of tranfmitting colour, but to be devoid of any reflective power.

In the examination of fome animal fubjects, when the colouring matter could not be feparated from the white fubftance by chemical means, he had recourfe to mechanical methods of effecting their divifion. But fuch methods, he confeffes, can only be employed when the principle part of the white fubftance is unmixed with the coloured coat or covering which is fpread upon it's furface.

To conclude, from all the experiments and obfervations of Delaval, it appears that all colouring matter, whether animal, vegetable or mineral, is tranfparent; that it does not reflect colours, but exhibits them by tranfmiffion only; and that opake coloured bodies confift of tranfpa-

rent matter, which covers opake white particles, and tranfmits the light that is reflected from them; and this white fubftance which compofes animal and vegetable bodies confifts principally of calcareous earth. All colouring matter is black when viewed by incident light, and all fubftances incline to blacknefs in proportion as they are copioufly ftored with tingeing particles.

Bergman appears to have been the firft who obferved that the colouring matter of bodies poffeffes chemical properties that diftinguifh it from all other matter; for befides it's feveral affinities with particular rays of light, it has others which render it fufceptible of being acted upon and modified by a variety of chemical agents, and of forming permanent combinations with other fubftances, fuch as the filaments of wool, filk, cotton, linen, &c. This matter poffeffes chemical properties.

It is from thefe affinities that the art of dying arifes, and thofe beautiful colours communicated that fo much adorn the elegancies of tafte; fince, however, thefe affinities are of various ftrength, fome being ftrong enough to form with the fubftance to be dyed a permanent colour, whilft others require an intermedium to unite them together, colouring matters have been divided into two kinds: Two kinds of colouring matters.

1. Thofe the attractions of which for the particles of the different ftuffs are fufficiently ftrong of themfelves for the colour to be fixed, have been called by Dr. Bancroft *fubftantive* colours. Subftantive.

2. Thofe of which the attractions are not fufficiently ftrong of themfelves, but require fome earthy, metallic, or other body that has an attraction for both, by which a bond of union is formed and the colour fixed, are called *adjective* colours. Adjective.

3. The body that is interpofed is called the *mordant* or Mordant.

Amongſt the firſt may be reckoned the Tyrian purple; and amongſt the ſecond, the different red colours of the animal kingdom, for which we are indebted to the inſect tribes. The *purple* is ſuppoſed to have been produced by a ſnail, a ſpecies of murex, and the *red* is taken from ſeveral ſpecies of the genus coccus of the order hemiptera of inſects, ſuch as the coccus cacti, ilicis, lacca and polonicus. According to Olivier, uſeful colours may likewiſe be obtained from the coleoptera order, particularly one from the meloe proſcarabœus; and in America there is a large green worm which infeſts the tobacco plant; this when bruiſed affords a conſiderable quantity of a green liquor that might be uſeful as a dye. Thus whilſt a few of the mammalia regale us with their excellent perfumes, theſe ſmaller tribes add their tribute to the arts of man, by preſenting him with the moſt rich and brilliant of colours.

TYRIAN PURPLE.

Tyrian purple.

THE origin of the diſcovery of the famous purple ſo much boaſted of by all antiquity is perhaps unknown. Tradition has handed down to us different accounts of it.

It's diſcovery and great antiquity.

It is related, that a ſhepherd's dog, being preſſed with hunger, broke a ſhell upon the ſea ſhore, when the blood that ran from it ſtained his mouth of ſo beautiful a colour as to ſtrike the admiration of thoſe that ſaw it; they endeavoured to make a dye of it, and ſucceeded. Another account is, that at the time Hercules was in love with the nymph Tyros, his dog happening to find a ſhell on the ſea ſhore, broke it, and his mouth was ſtained with the purple. The nymph obſerving it, and charmed with the richneſs and beauty of the colour, declared to her

lover, ſhe would ſee him no more until he brought her a garment dyed with the purple. Hercules ſucceeded by collecting a number of ſhells, and brought the purple robe ſhe had demanded.

Some place this diſcovery in the reign of Phœnix ſecond king of Tyre, about 500 years before Chriſt; others at the time that Minos the firſt reigned in Crete, about 1439 years before the chriſtian æra. The greater number of authors, however, give the honour of the invention of dying ſtuffs purple to the Tyrian Hercules. He gave his firſt trials to the king of Phœnicia, and that prince became ſo jealous of it's beauty, that he forbade it's uſe to all but his deſcendants and the preſumptive heir of the crown. With reſpect to the explication of the fable of the diſcovery, we are informed by Bochart, that in the Syriac language the ſame word ſignifies *a dog* and *a dyer*, which the Greeks applied to the former animal. The antiquity however of the diſcovery, as obſerved by Goguet, is confirmed by the teſtimony of Homer, who gives purple ornaments to heroes who lived about the age in which it is ſaid to have been made known.

Whence extracted.

The purple dye was drawn from many kinds of ſea-ſhells, but the beſt were found near the iſle where new Tyre was built. They likewiſe fiſhed for them in other places on the Mediterranean. The coaſts of Africa were famous for the purple of Getulia, and the coaſts of Europe ſupplied the purple of Laconia, which they held in great eſteem.

Account of Ariſtotle and Pliny.

According to the accounts of Ariſtotle and Pliny, to whom poſterity is indebted for almoſt the only account, it was obtained from an univalve ſhell fiſh. Pliny, in whoſe time it ſeems this dye had attained it's greateſt perfection, divides the principal ſhell fiſh which afforded it into two ſpecies; the firſt, comprehending the ſmall ſpecies, he called buccinum or whelk; the ſecond included

thofe called purpura, and were of a larger fize. Both fpecies were fubdivided into feveral varieties; they were likewife diftinguifhed by the more or lefs beautiful colour they gave, and according to the coafts where the fifhery was carried on. Thefe are fuppofed by Fabius Columna to have been alfo diftinguifhed by the generic name of murex. The juice was contained in a fmall vein found in the body of the buccinum quite colourlefs; it likewife, when broken, contained a very fmall quantity of a red liquor fhaded with a black tinge, the nigricans rofa of Pliny. The colouring juice of the purpura was found in a veffel in the throat, but fo fmall was it in quantity that only one drop could be extracted from each animal.

It's preparation.

When a fufficient quantity of the colouring juice was extracted, a certain portion of marine falt was added to it; it was then macerated for three days, after which five times the quantity of water was added, the mixture kept in a moderate heat, and the animal parts which rofe to the furface were feparated from time to time. Thefe operations lafted ten days, after which the liquor was tried whether it had taken the proper degree of colour by means of a piece of white wool.

Methods of dyeing with it.

Previous to the dyeing, the ftuff was differently prepared; fome dipped it in lime-water, others made ufe of a fpecies of fucus which acted as a mordant to render the colour more fixed. We are informed, that the liquor of the buccinum did not afford a fixed colour of itfelf, but it increafed the brightnefs of the colour of the purpura. In dyeing the Tyrian purple, they began with the juice of the purpura, then a fecond dye was given with that of the buccinum; hence Pliny gives it the name of *purpura dibatha*. In other proceffes, the juices of the two were mixed; for inftance to dye 50lb. of wool, 200lb. of the buccinum, and 100lb. of the juice

of the purpura were taken, by which means an amethyſt colour was obtained; ſometimes a *ground* was given with the coccus (the modern kermes), and afterwards the juice of the purpura was uſed. Likewiſe a great variety of purples were obtained by uniting ſome of theſe methods, which were diſtinguiſhed by different names; thus, according to Pliny, that of Tyre was of the colour of coagulated blood, the amethyſt purple took it's name from the ſtone, another ſpecies reſembled violet, &c. It appears that ſome kinds of purple preſerved their colour a long time, for it is related by Plutarch in the life of Alexander, that the Greeks found a great quantity of purple in the treaſury of the king of Perſia, the beauty of which had not changed during 190 years.

It's dearneſs.

The very ſmall quantity of juice extracted from theſe animals, and the length of the operation of dyeing, made the purple of ſo high a price, that at the time of Auguſtus one pound of wool dyed with the Tyrian purple could not be bought for thirty pounds. It is ſuppoſed from the commerce of this precious dye, that it contributed much to the opulence of that once celebrated city. From it's great price it was, as may be ſuppoſed, an attribute every where of high birth and dignities, the purple therefore decorated the firſt magiſtrates of Rome; but as it ſoon became leſs ſcarce amongſt the opulent, it was at laſt reſerved, under pain of death, to the emperors; whilſt the prieſts, every where buſy, canonized it as a colour agreeable to the divinity, and which when firſt known was arrogated by them for his worſhip.

Rediſcovered by the moderns.

For many centuries nothing was known reſpecting the two juices which formed the Tyrian dye, except what the ancients had left us; ſo that although Ariſtotle and Pliny had given ſome intimations of their being primitively white, and Pliny had mentioned one of the intermediate colours or green which takes place, yet the other

colours they undergo on expofure to the rays of the fun, were not diftinctly noticed, until the animals which afford them were difcovered at the end of the laft century and the beginning of the prefent. It was not till then that any adequate conceptions could be formed of the changes they underwent before they became purple.

Cole and Reaumur difcover the buccinum.

For the identity of the fhell fifh of the ancients with thofe of the moderns, we are indebted to Duhamel, who difcovered the purpura, and to Cole and Reaumur who found the buccinum.

The buccinum.

With refpect to the buccinum, it was found in 1686 by Cole in great plenty on fome of the Irifh fhores, on the fhores of Somerfetfhire, and the oppofite ones of South Wales, and confiderable profit was made of it by marking linen with it's juice of a fine durable crimfon colour. A fmall fpecies of the buccinum was likewife found by Juffieu on that part of the French coafts which is wafhed by the Atlantic; it refembled in form the garden fnail, and was prefented to the Royal Academy at Paris in 1709, whilft in the following year Reaumur found great quantities on the coaft of Poitou. The fhell of the buccinum, which is confiderably hard, is firft broken by a fmall blow, taking care not to crufh the body of the fifh within. After picking off the broken pieces, Cole found the juice in a little white vein or refervoir, lying tranfverfely in a fmall furrow or cleft near to the head of the fifh; this white liquor being taken out is clammy, and if characters be drawn with it, or if it's vifcid juice be fqueezed upon linen or filk, the part acquires immediately on being expofed to the fun, a pale yellowifh green, which quickly deepens into an emerald green, then changes to a blue, and laftly to a deep purple red. This fucceffion comes on fo quickly as fcarcely to be diftinguifhed, and the changes are made quicker or flower, according to the degree of the fun's heat. If the cloth be now wafhed with fcald-

ing water and ſoap, and laid again in the rays of the ſun, the colour changes to a beautiful crimſon; which ſuffers no further alteration from ſun or air, or any of the ſubſtances uſed for aſſaying the permanency of colours. Cole likewiſe found, that whilſt linen marked with this white liquor was drying by expoſure to the ſun during the firſt time, it always yielded a very ſtrong fetid ſmell reſembling a mixture of garlick and aſſa fœtida; it appears alſo that the purple of the ancients had a ſtrong ſmell.

Du Hamel diſcovers the purpura.

With reſpect to the purpura, we are informed by du Hamel that it's juice receives no colour, nor communicates any, either to ſilk or linen, without expoſure to the ſun; that it is the light and not the heat of it's rays that calls it's colour forth; for when the ſilk or linen is covered with thin opake bodies which tranſmit heat without light, no colour is produced, whilſt tranſparent bodies do not impede it. Likewiſe the light of a culinary fire concentrated by convex glaſſes and concave mirrors has no effect upon it. Du Hamel, who found the viſcid colouring liquor of this fiſh white, except in a few inſtances where it was green, and which he ſuppoſed originated from diſeaſe, gives the colours it aſſumed on expoſure to the ſun in the following order. 1ſt. A pale green or yellow. 2d. an emerald green. 3d. a dark bluiſh green. 4th. a blue with an incipient redneſs. 5th. a purple. Theſe colours took place in leſs than five minutes, and it only became green when not expoſed to the light. According to Lewis, this ſucceſſion of colours is beſt obſerved when the ſun is low and his action is weak, whilſt at noon in ſummer they are ſo quick as not to be eaſily diſtinguiſhed. Du Hamel found it in great abundance on the coaſts of Provence. Snails poſſeſſing the ſame property are found to exiſt in various parts of the world. From the account of John Nieuhoff, there are an abun-

Others posſeſſing the purple colour.

dance of purple ſnails found in the iſlands over againſt Batavia, and it appears that the Chineſe have the cuſtom of eating them, at the ſame time they pick out of the middle of the animal a purple coloured ſubſtance which they uſe as red ink. According to Dr. Peyſonnel a naked ſnail, producing a purple colour, is found in the ſeas of the Antilles; and is looked upon as precious for the beautiful purple colour it produces, which is purple without the aid of light. It is emitted in the ſame manner as the black ink of the cuttle fiſh or ſepia, which when in danger ſurround itſelf with it's viſcid bitter black fluid; this laſt was uſed as ink by the Romans, and is ſaid at this time to form the baſis of the Chineſe or Indian ink.

In the hiſtory of Jamaica by Dr. Brown, is a deſcription of two ſhell fiſh containing a ſimilar purple colouring liquor. The one is termed the *larger dark lernea* or *ſea ſnail*, and is very frequent in the American ſeas. On touching this animal, he obſerves, it emits a conſiderable quantity of a viſcid purple liquor, which thickens and colours the water ſo much, that it is ſcarcely to be ſeen for ſome time, by which means, like the cuttle fiſh, it eſcapes danger. This liquor colours linen of a beautiful dark purple, not apt to be changed either by acids or alkalis, but it differs from that of the buccinum by being readily waſhed out, as well as being naturally emitted of a purple colour. The other of theſe ſhell fiſh is called the *purple ocean ſhell*, and on being touched it emits a liquor reſembling the former.

To theſe it may be added on the authority of Reaumur, that on ſome of the French coaſts he found great numbers of ſmall elliptical ſpheroidal bodies adhering to the rocks by a ſhort ſtem like fruits, and that the purple fiſh were commonly accumulated plentifully about theſe. On examination of the bodies he found them to be veſi-

cles filled with a liquor of the ſame quality as the juice of the fiſh, but leſs viſcid and more readily ſpreading upon linen. At firſt he ſuſpected them to be eggs, perhaps of the purple fiſh, but could not obſerve any thing like them on diſſection. They are only in perfection in autumn, whilſt in ſummer they have either loſt their colouring juice, or the juice it's power of becoming purple in the ſun. And Gage relates that ſome ſhell fiſh were found near Nicoya, a ſmall Spaniſh city in South America, which had all the properties deſcribed by the ancients, as Pliny, &c. It even appears that ſome uſe is made of them in dyeing cotton on the coaſts of Guajaquil and Guatimala.

The colours of the Portugueſe men of war, or holuthuria phyſalis of Linnæus, preſent, ſome of them a beautiful crimſon, others a fine purple, and Dr. Bancroft procured a fluid of the ſame purple colour, with which he ſtained the corner of a cambric handkerchief that ſuſtained nine months repeatedly waſhing without loſing much of it's colour. This liquor was very acid.

It is obſerved by Martin Liſter in the Philoſophical Tranſactions, that the common hawthorn caterpillar will ſtrike with lie a purple or carnation colour that will ſtand; likewiſe the heads of beetles and piſmires will give an equally fixed carnation colour; and he adds, that the amber coloured ſcolopendra affords by means of lie a moſt beautiful amethyſt colour equally durable, whilſt eggs of a cimex bruiſed upon white paper, communicate alone a lively and bright vermilion colour.

From this account of the Tyrian purple, it appears that it is not loſt; if, however, modern artiſts have neglected to procure it, if they have not endeavoured to profit from the eſſays already mentioned as made by their contemporaries, it is becauſe colours have been acquired that are not only more beautiful but leſs dear. We have be-

ſides what has been deſcribed a very detailed deſcription of the manner in which the ancients fiſhed for the ſhell fiſh that afforded the purple, in a work compoſed by Eudocia Macrembolitiſſa, daughter of the emperor Conſtantine the Eighth, who lived in the 11th century. This lady was an eye witneſs of the account ſhe wrote.

Cochineal. The inſect from which that beautiful rich red colour called crimſon is taken is of the order hemiptera, named by Linnæus, coccus cacti. According to Berthollet, it is ſometimes oviparous, and at other times viviparous. The male only lives a month, which it ends with it's amours, and the female only ſurvives him the following month, and dies after parturition. This inſect is an inhabitant of the province of Mexico, and other Spaniſh parts of South America, where it is bred and collected in large quantities; the commerce it gives riſe to being eſtimated at many millions of Dollars annually. It's food is the leaf of the Indian fig, or prickly pear tree, the cactus opuntia of Linnæus. It is likewiſe called nopal.

Where found.

In the country from which it is brought it is guarded with great care and jealouſy, to prevent foreigners from tranſplanting it into other countries. Several attempts have, however, been made to procure it. Thiery of Menonville had the courage and patriotiſm to expoſe himſelf to the greateſt riſks, by going to Mexico to obſerve the education of this inſect; and he was ſo fortunate as to convey this precious production into the iſland of St. Domingo; but no accounts have been lately received of it's proſperity.

When the females are ſcattered on the plant, and the young are obſerved to proceed from them, they begin their culture. They are afterwards killed by boiling water, and dried with great care in the ſun, by which exſiccation they loſe nearly $\frac{2}{3}$ of their weight.

According to Spallanzani, in his travels through the

Two Sicilies, this inſect might be advantageouſly tranſplanted to the Lipari iſlands and Sicily, where the plant they feed upon grows with more luxuriancy than in South America.

From the external appearance of cochineal, and from the ſecrecy with which it's nature was preſerved, it was for a long time ſuppoſed to be the entire fruit or berry of the tree, that had been wrinkled and ſhrivelled by the drying, and when the fruit or pear was known, it was then ſuppoſed to be the ſeeds of it. It is a ſmall, irregular, roundiſh body, and internally of a red colour. Acoſta was one of the firſt eye witneſſes of it's being an inſect; and Sir Hans Sloane, Plumier, and all the later travellers into America, confirm his account of it.

It's varieties in commerce.

The dried cochineal is ſorted into two kinds, viz. into the large entire grains, called by the Spaniards, *grana*, and into ſmall or broken ones, which they call *granilla*. In trade, four ſorts are diſtinguiſhed: meſteque, campeſchane, tetræſchale, and ſylveſter, of which the firſt is accounted the beſt, and called *grana fina*, and the laſt the worſt, called by the Spaniards, *grana ſylveſtra*. The three former are named from the places in which they are produced; the latter, from it's being found wild, without any culture.

According to Neuman, thoſe ſorts of opuntia, the fruit of which is of the deepeſt red colour, are obſerved to produce the fineſt cochineal; but although the colour of the fruit of this plant is red, we are informed by Thiery, that the juice which this inſect feeds upon is greeniſh, and that it will live and perpetuate it's ſpecies on thoſe kinds of opuntia of which the fruit is not red.

The large or *grana fina* is not covered with a cottony down like the other, which down being uſeleſs in dying, equal parts afford more colour, and it is of a ſuperior price to that of *ſylveſtra*; but, perhaps, theſe advantages

are oppofed by it's more expenfive education, and by it's having no down, which caufes it not to refift the rain and ftorms fo well as the other.

The grana *fylveftra*, raifed from the nopal, lofes in part the tenacity and quantity of it's cotton, and becomes double the fize to what it does on the other fpecies of opuntia. It is therefore to be hoped, that by a continued fyftem of education, it will become more perfect, and approach by degrees the grana *fina*.

Properties of the beft.

The fine, or beft cochineal, when well dried and preferved, is fomewhat heavy; moderately compact; clean, and of a gloffy furface, of a gray colour, tending to a purple. The gray colour is owing to a powder which covers it naturally, and a part of which ftill remains; the purple fhade is owing to the colour the water has extracted on deftroying them. When chewed it tinges the fpittle of a deep brownifh red colour called crimfon, and impreffes on the organs of tafte a kind of faint and not very agreeable favour. When thoroughly dry, it has no fmell; when moift, it is fomewhat mufty.

This infect may be preferved a long time in a dry place. Hellot fays, that he tried cochineal 130 years old, which was as good as new.

Experiments of Berthollet.

On comparing the fylveftra cochineal of Mexico, and fome fent from St. Domingo by Bruley, with the mefteque, Berthollet found that the decoction of the fylveftra has the fame fhade as that from St. Domingo; that this fhade tends more to the crimfon than that of the mefteque; but the precipitates obtained either by folution of tin or by alum, are exactly of the fame colour as that of the mefteque; and it is thefe precipitates, that, by combining with the ftuffs, give them their colour.

In order to determine the proportion of colouring matter the decoctions of the different cochineals contained, this chemift made ufe of the oxygenated muriatic

acid. He boiled an equal weight of each of the three cochineals for one hour; he poured each of the decoctions, when filtered, into ſeparate graduated glaſs cylinders, and then added oxygenated muriatic acid to them until the three were brought to the ſame yellow hue, and the quantities of acid that indicated the proportions of the colouring matter were found exactly as follows, viz. eight for the cochineal of St. Domingo; eleven for the ſylveſtra of commerce, and eighteen for the meſteque.

Hence the cochineal of St. Domingo is not only very inferior to the meſteque, but even to the ſylveſtra of Mexico, and in reality it is much more downy and ſmaller; but the obſervations of Thiery have proved, that the ſylveſtra, by a ſucceſſion of generations, if carefully attended to, loſes part of it's down, and becomes much larger; hence it is to be hoped, that the cochineal of St. Domingo may, by care, be brought to the ſtate of perfection of the Mexican, and perhaps, to ſurpaſs it.

Water, by decoction, extracts ſome of the colouring matter of cochineal; and the colour, according to Berthollet, is of a crimſon, inclining ro a violet. Water, however, does not extract all, and the remaining colouring matter, Dr. Bancroft found to be extracted (which is about $\frac{1}{8}$ of the whole) by the addition of ſoda to the reſiduum, and a freſh ſupply of boiling water. If this be evaporated, and the extract digeſted in alcohol, the colouring parts are diſſolved, and afford a reſiduum that only retains the colour of wine lees, of which a new addition of alcohol cannot deprive it. This part, on analyſis by fire, affords the ſame products as other animal ſubſtances.

The alcohol of cochineal, on being evaporated, leaves a tranſparent reſiduum of a deep red colour, which, when dried, has the appearance of a reſin. It gives likewiſe on diſtillation, the products of animal ſubſtances, a con-

vincing proof that this colouring matter is an animal production.

The decoction of cochineal enters, with difficulty, into putrefaction; and on preserving it more than two months, both expofed to the air, and in a clofed bottle, the firft prefented no fymptom of putrefaction; the fecond had a flight putrid odour. The firft became turbid almoft at the beginning, and left a brown violet fediment on the filter; the fecond preferved it's tranfparency a long time, and, perhaps, only loft it from the effect of the incipient putrefaction, or rather, according to Berthollet, from a flight combuftion that was occafioned by a little oxygen that had probably united to the red particles of the cochineal. The colour of both had become crimfon, the firft, however, was weaker from the greater part of the colouring particles being precipitated in confequence of certain effects produced by the air.

Berthollet, on trying the different effects which a variety of chemical agents had upon the colouring matter as it exifted in the decoction, found, that the fulphuric acid in fmall quantity gave this liquor a red colour tending to a yellow, and a beautiful red precipitate fell to the bottom.

The fulphat of foda produced no evident change.

The fulphat of iron formed a brown violet precipitate, and the liquor remained clear, with a tinge of dead leaf (*feuille morte.*)

The fulphat of zinc produced a deep violet precipitate, and the liquor remained clear and colourlefs.

The fulphat of copper produced a violet depofit, that was very flowly formed, and the liquor remained clear, and of a violet colour.

The muriatic acid produced nearly the fame change as the fulphuric; but without any precipitation.

A solution of muriat of soda gave a deep rose coloured precipitate without rendering the liquor turbid.

Muriat of ammoniac produced a shade of purple, without any precipitation.

The acetite of lead produced a purple violet coloured precipitate, but less deep than the sulphat of zinc; the liquor remained limpid.

A solution of tartar changed the liquor to a yellowish red, and a small precipitation took place of a pale red colour, whilst the supernatant liquor remained yellow. On pouring a little alkali into it, it became purple. The alkali rapidly dissolved the small quantity of precipitate, and the solution was purple. A solution of tin formed with the yellow liquor a rose coloured precipitate.

Having boiled a little cochineal with half it's weight of tartar, the liquor became more red, and had a much less deep colour than an equal quantity of cochineal without tartar; but the first gave, with a solution of tin, a more abundant precipitate, more of a rose colour, hence tartar favours the solution of the colouring parts of the cochineal; and although the colour of the solution be less deep, the precipitate produced from it by the solution of tin has a deeper and more rosy hue. This experiment, Berthollet thinks, deserves some attention, in order to judge of the influence of the tartar in the process of dying scarlet.

A solution of tartar being poured to the liquor of decoction, and afterwards a solution of tin, a deposit was more readily formed than by tin alone, which was of a rose colour tending to a lilac, and although an excess of the solution of tin was added, the liquor remained somewhat yellow.

A solution of alum brightened the colour of an infusion of cochineal, and gave it a redder hue, a crimson

precipitation took place, and the liquor retained rather a reddiſh crimſon colour.

A mixture of alum and tartar produced a brighter colour, more lively, and tending to a yellowiſh red; a precipitation took place, but much leſs in quantity, and much more pale than in the preceding experiment.

A ſolution of tin formed a large depoſit of a beautiful red colour; the liquor was clear as water, and no change of colour took place on the addition of an alkali.

Dr. Bancroft.

For a more extenſive inveſtigation of the colouring matter of cochineal, and the various colours produced upon it by different agents, we are indebted to the labours and inveſtigation of Dr. Bancroft. He has particularly paid attention to the method of producing, with this colouring matter of cochineal, which is naturally a crimſon, that moſt beautiful and ſplendid of all others, the ſcarlet colour, the richeſt of any that the art of dying has been able to produce. The ſhades of this ſcarlet colour are known to be various, from a more or leſs deep red, to a more or leſs vivid fire coloured ſcarlet; but as the common operations were inſufficient to produce theſe ſhades, other experiments were neceſſary, which appear to have been made with great accuracy.

Diſcovery of ſcarlet.

It is moſt probable, for many years, that cochineal was made uſe of in Europe as a dye, the aluminous baſis was the only mordant employed for this purpoſe. An opportunity, however, accidentally occurring to Kepſler, a German chemiſt, of ſeeing the wonderful effects of a ſolution of tin by the nitrous acid in exalting the colour o. this ſubſtance, the diſcovery of the cochineal ſcarlet was the conſequence. Kepſler, or as he is ſometimes called, Kuſter, brought his ſecret to London, in 1543; ſuch is the account which Kunckel gives of the diſcovery of his countryman.

It has been generally ſuppoſed by writers on this ſubject, that after the effect of tin upon the cochineal colour had been diſcovered, nothing was wanting to produce ſcarlet than to apply the colour ſo produced, as a dye to wool; or in other words, that a nitric or nitro-muriatic ſolution of tin was ſufficient to change the natural crimſon of cochineal to a ſcarlet. This, however, Dr. Bancroft eſteems as an erroneous opinion, for this ſolution only produces a crimſon or roſe colour, and not a ſcarlet; unleſs other means be employed to incline the cochineal colour, as far as may be neceſſary, toward a yellow hue; and the means of doing this ſeem to have been ſtumbled upon without any knowledge of their real effect. Tartar was, and is the uſual mordant for the dying of woollen cloths, as it gives the cochineal the yellowiſh tendency neceſſary to produce a ſcarlet. This chemiſt found, on inquiry, that ſcarlet was a compound colour, conſiſting probably of $\frac{3}{4}$ of a moſt lively pure crimſon or roſe colour, and $\frac{1}{4}$ of a pure bright yellow. Now the great deſideratum was, to find out a yellow from other drugs, equivalent to the converſion of $\frac{1}{4}$ of the cochineal colouring matter from it's natural crimſon to the yellow colour. The muriatic ſolution of tin appeared the beſt as a mordant, as it fixed and reflected the pure crimſon or roſe colour of the cochineal unchanged and with the utmoſt brightneſs. Alum, though it fixes it's colouring particles more durably, degraded or altered the natural colour of the cochineal ſolution, as well as ſolutions of all the earths and metals, tin excepted. To produce a ſcarlet, therefore, it was only neceſſary to ſuperadd and intimately combine with this crimſon or roſe colour, a ſuitable portion of a lively golden yellow, capable of being properly fixed and reflected by the baſis. Such a yellow Dr. Bancroft found in the quercitron bark (quercus nigra Lin.) and in young fuſtic (rhus cotinus Lin.) although

A compound colour of crimſon and yellow.

Produced by quercitron bark,

and murio-sulphuric solution of tin.

the laſt is much leſs bright and leſs durable. The quercitron bark is not only the brighteſt but the cheapeſt of all yellows; for according to this chemiſt, 1 pound of the powdered bark, which only coſt three pence farthing, with a ſufficient quantity of muriat of tin, dyed between 30 and 40 pounds of woollen cloth of a full bright golden yellow, and this being afterwards dyed in the ſame liquor with ¼ leſs of cochineal than what is uſually employed, acquired a ſcarlet equal in beauty and durability to any that is uſually given by ordinary means with a full proportion of cochineal. He found that three pounds of muriatic acid, which only coſt one ſhilling, might be made to diſſolve a pound of tin, that would require eight pounds of ſingle aqua fortis to diſſolve; and that the muriatic had likewiſe this advantage, that a ſolution made by it was as tranſparent and colourleſs as the pureſt water, and capable of being preſerved for many years without the leaſt alteration, whilſt the nitro-muriatic ſolution of tin, or ſpirit of the dyers, becomes turbid and gelatinous very ſpeedily, and even in a few days if the weather be warm; it may alſo be added, that the muriatic ſolution ſeems to exalt the colour both of the quercitron bark and of the cochineal more than any other. He likewiſe ſaved all the tartar employed in the old proceſs, and extracted, by potaſh, a part of the colouring matter of the cochineal, ſuppoſed to have been before always loſt, and obtained by means of the bark, as much yellow as was required for the compoſition of this colour with the cochineal crimſon, inſtead of converting any part of this laſt more coſtly colour into a yellow. He found, however, that the muriat of tin poſſeſſed a very corroſive property; hence he uſed the nitrat of tin, which he found, contrary to his expectation, (when unmixed with tartar) only to produce a crimſon, but that if tartar was employed either with the muriatic or nitric ſolutions of the metal, a ſcarlet colour was the

consequence. The contrary to this was the general opinion; for according to Berthollet, tartar gives a *deeper* and more *rosy hue* to the colouring matter of the cochineal, precipitated by the solution of tin, and it moderates the action of the nitro-muriatic acid, which tends to give scarlet an orange cast. After various experiments, therefore, Dr. Bancroft found, that the best was a solution of about fourteen ounces of tin in a mixture of 2 pounds of oil of vitriol with three pounds of muriatic acid. The muriatic acid is to be first poured upon a large quantity of granulated tin, in a large glass receiver, and the oil of vitriol afterwards added slowly; these acids being mixed are left to saturate with the tin; this solution is more rapidly promoted by a sand heat. This murio-sulphuric solution of tin is perfectly transparent and colourless, and remains so many years; it produces full twice as much effect as the dyers spirit or nitro-muriatic solution of tin, with less than $\frac{1}{3}$ of the expense. It raises the colour more than the dyers spirit, and full as much as the tartrite of tin, without changing the natural crimson of the cochineal towards the yellowish hue, and is the best mordant or basis for producing a compound scarlet, with the cochineal, crimson, and quercitron yellow, in which operation $\frac{1}{4}$ of the cochineal may be saved. To this it may be added, that by using the quercitron bark, not only $\frac{1}{4}$ of the cochineal is saved, but the scarlet composed of these two may be dyed upon woollen and linen yarn without any danger of it's being changed to a rose or crimson by the process of fulling, as always happens to scarlet dyed by the ordinary means, and if it be compared with the common scarlet by candle light, it appears at least to be several shades higher and fuller, and is not to be spotted or changed by chemical agents, such as calcareous earth, soap, alkaline salts, &c.

The procefs.

The procefs is to put the cloth to be dyed fcarlet into a proper tin veffel nearly filled with water, with which about eight pounds of murio-fulphuric folution of tin have been previoufly mixed; the liquor is then boiled, turning the cloth through it as ufual for ¾ of an hour, the cloth being then taken out, four pounds of cochineal and two pounds and a half of quercitron bark, are to be added in powder; having mixed them well, the cloth is to be returned into the liquor, the boiling and operation continued until the colour is duly raifed, and the dying liquor exhaufted, which is in about fifteen or twenty minutes; the cloth is then taken out and rinfed as ufual. By this method the time, labour, and fuel neceffary for a fecond procefs will be faved, the operation finifhed more fpeedily, and a faving of all the tartar, ⅔ of the coft of fpirit or nitro-muriatic folution of tin, and ¼ of the cochineal ufually employed, and the colour is not inferior to that dyed in the ordinary way; and as to the fcarlet, every poffible fhade between the crimfon and the yellow colours may be produced by only increafing or diminifhing the proportion of bark. If a crimfon or rofe colour is wanted the bark is omitted.

Effects of metallic and earthy bafes on the colouring matter of cochineal.

It remains to give an account of the experiments Dr. Bancroft made to difcover the effects which metallic and earthy bafes have upon the colouring matter of cochineal.

1. Effects of metallic bafes upon woollen cloths with the colouring matter.

The nitro-muriat of platina produced with cochineal, a red, which by the addition of chalk, became a chefnut colour.

Cochineal with nitro-muriat of gold, a reddifh brown.

With nitrat of filver, a dull red, and with muriat of filver, a lively reddifh orange.

All the preparations of copper appear to fadden and debafe the colouring matter; and thofe of mercury, in a

much greater degree, and they appear likewiſe to annihilate a conſiderable part of the colour as well as debaſe it.

With the acetite of lead, a purple colour, inclining to the violet, is produced. With nitrat of lead, a delicate lively colour, between red and cinnamon, but more inclining to the former. A little murio-ſulphat of tin added to the laſt, changed it to a good crimſon.

With either the ſulphat, nitrat, muriat, or acetite of iron, a dark violet, and even a full black colour is produced, when the cochineal is in ſufficient quantity.

The oxyd of tin (formed by means of aqua fortis) with an equal quantity of cochineal, gave, on boiling, a full equal crimſon, ſomewhat deficient in brightneſs. Tartar or lemon juice being added, a good ſcarlet was produced. By ſubſtituting cauſtic volatile alkali for theſe two laſt, there aroſe a crimſon colour, greatly inclining to a purple. Hence Dr. Bancroft is of opinion, that the oxyd of tin does not act in all caſes, *merely as ſuch*, but it's effects often depend on triple, quadruple and ſometimes even more complex combinations, in which different ſaline and other parts of the compound remain permanently united, at leaſt where the ſhades of colour depending on them are found permanent. Hence ſea ſalt, and other purely ſaline matters, having no earthy or metallic baſis, cannot become the baſis of any adjective colour, but produce *laſting* effects in modifying and varying the complexions of different colours. It muſt, however, be obſerved, that this oxyd, although after being well waſhed and dried, it was capable of dying a crimſon on woollens with cochineal, and a ſcarlet, where either tartar, lemon juice, or quercitron bark were added, would not permanently combine with, or become the baſis of theſe colours upon cotton; and on woollen it was only the finer particles of the calx that really combined with the colouring matter and the wool, the groſſer being always diſtinctly

found at the bottom of the veſſel; it is likewiſe neceſſary that the oxyd and the colouring matter ſhould be previouſly mixed together, and exert their mutual attractions upon each other before they can be properly taken up by the cloth.

Cochineal with nitrat of tin produced a fine crimſon, and when the cloth was boiled in the ſame with tartar, it was changed to a good ſcarlet. Tin diſſolved immediately in a mixture of aqua fortis and tartar produced a ſcarlet much more and highly beautiful. Refined ſugar or alcohol added in the formation of nitrat of tin rendered the ſolution unfit to combine with the fibres of the cloth, or ſerve as a mordant.

With a ſolution of tin by muriatic acid, it dyed a beautiful crimſon, and with a ſolution of that metal, by a mixture of tartar and muriatic acid, a beautiful ſcarlet. The acid of tar added with the muriatic ſolution, produced a dark crimſon; and with tin and a little manganeſe in the muriatic acid, a very bluiſh crimſon. Borax with the muriatic ſolution of tin, dyed a very good crimſon.

With tin calcined by the long continued action of ſulphuric acid, it dyed a ſalmon colour; and with a recent ſolution, a reddiſh ſalmon colour, inclining a little to the crimſon. The ſame colour was produced with tin diſſolved in equal parts of ſulphuric and nitric acids. Oil of vitriol poured on tartar and granulated tin became black, and this tartaro-ſulphurie ſolution with cochineal gave an aurora colour.

With a ſolution of tartrit of tin a very beautiful ſcarlet was produced, inclining a little to the aurora. A ſimilar colour was made by water ſaturated with cream of tartar in which granulated tin had been kept ſix weeks.

With the citrat of tin, a ſcarlet of which nothing can exceed the beauty, and inclining like the preceding, a

little to the aurora. This citric acid with tin is found to act at leaft as efficacioufly as that of tartar, in yellowing the cochineal crimfon.

With acetite of tin, a fcarlet inclining a little to the crimfon; the folution had an unpleafant fmell.

With tin diffolved by acid of tar, a colour was produced between the fcarlet and crimfon fhades.

With phofphat of tin, an aurora colour.

With fluat of tin, a very good fcarlet.

Cochineal, with nitrat of zinc, produced a lively ftrong lilac colour.

With muriat of zinc, a colour like the preceding, but inclining a little more to the purple. Dr. Bancroft thinks that probably the iron ufually contained in zinc may have contributed in thefe inftances to incline the cochineal crimfon fo much to the blue or violet fhades, fince a purer oxyd of zinc, the lapis calaminaris, diffolved in muriatic acid gave a fcarlet with cochineal, but very little inferior to that commonly produced by the nitro-muriat of tin and tartar, and upon adding a little murio-tartrit of tin to the dying liquor, a very beautiful fcarlet was the confequence; hence the pure oxyd of zinc appears to this chemift to approach neareft to that of tin, in exalting the colouring matter of cochineal.

With different folutions of bifmuth, various fhades of lilac were produced, fome of which were very lively and delicate; but all the preparations of this femimetal, inftead of difplaying and exalting the cochineal colour, tended to render a part of it latent. The acetite of bifmuth did this lefs than moft of them, it gave a pretty good purple, and the murio-fulphat of bifmuth a falmon colour.

With nitrat of cobalt, a good purple was produced.

With nitrat of nickel, a dark lilac, inclining to the violet.

With ſulphat of manganeſe, an orange colour, with nitrat of manganeſe, a colour reſembling the madder red.

With a ſolution of crude antimony in nitric acid a ſcarlet was produced, very much like that with lapis calaminaris in the muriatic acid, and very little inferior to the beſt ſcarlets given with the tin baſis.

With the acidulous arſeniat of potaſh, or Macquer's arſenical neutral ſalt, a lively good purple colour was produced.

2. Effects of ſeveral kinds of earths as baſes for the cochineal colouring matter upon wool.

Alumine well waſhed, dried and finely powdered, appeared incapable of fixing or ſerving as a baſis of the cochineal colour, hence it differs materially from the powdered calx of tin. The ſame pulverized alumine, however, boiled with cream of tartar, was ſo far diſſolved by the acid as to produce a good crimſon, though not much better than that produced with the ſulphat of alumine or common alum. This alumine diſſolved by lemon juice dyed a very good rich full crimſon. Diſſolved by nitric acid, a good red colour, inclining to crimſon. In muriatic acid, a crimſon very little different from that produced with common alum.

Lime-water with cochineal dyed a purple, which took but ſlowly, and required long boiling. Sulphat of lime dyed a full dark red. Nitrat of lime, a lively red, approaching to a ſcarlet. Dr. Bancroft found that cloth boiled in water with nitrat of lime, and then dyed in clean water with cochineal and tin, diſſolved by aqua fortis and tartar mixed, received a good ſcarlet. Muriat of lime dyed with cochineal a purple. Cloth boiled with chalk and alum, and then dyed in clean water with cochineal, took a good crimſon, inclining to the bluiſh ſhade.

Sulphat of barytes not being ſoluble in water could not be tried. Muriat of barytes dyed a good lively purple with the cochineal, and nitrat of barytes nearly ſimilar, but inclining a little more to the crimſon.

Magneſia alone did not ſerve as a mordant. The ſulphat of magneſia (Epſom ſalt) dyed with cochineal a lively purple, though it took but ſlowly, and required long boiling. Acetite of magneſia gave a lilac colour.

Siliceous earth or powdered flints with pure potaſh, and diſſolved in a crucible by a violent heat, appeared at firſt not to have ſufficient affinity for the fibres of the cloth and the colouring matter, but on adding a little ſulphuric acid, ſo as to decompoſe and neutralize a part of the alkali, combined with the ſiliceous earth, the colour took freely and roſe to a *full rich pleaſing purple*, in which the red or crimſon predominated conſiderably, and this colour proved afterwards ſufficiently durable.

Hence it appears, that beſides the metallic oxyds and ſolutions, the aluminous, calcareous, ſiliceous, magneſian and barytic earths are capable of fixing and ſerving as baſes of the cochineal colouring matter.

3. On ſilk,

Dr. Bancroft repeated nearly all the foregoing experiments with ſilk, inſtead of wool, but found that in general the effects were leſs advantageous. Cochineal indeed, with the aluminous baſis, dyes the crimſon colour as well and as durably on ſilk as on wool, and the modes of producing a very laſting crimſon by theſe means are well known. The oxyds or ſolutions of tin, however, do not fix and reflect the cochineal colour on ſilk with the ſame degree of fulneſs and luſtre as upon wool; probably becauſe the former of theſe ſubſtances has leſs attraction than the latter for the calx of tin and the colouring matter of cochineal combined together; hence it

Dying of ſilk and wool.

has been found impoffible to dye a good lively fcarlet on filk, by the means which communicate that colour to wool.

This chemift, however, has given the following method of producing a fcarlet on filk. The filk is to be foaked for two hours in the murio-fulphuric folution of tin beforementioned, with five times it's weight of water, then taken and moderately preffed, then partly dried, and dyed as ufual in a bath of cochineal and quercitron bark, four of the firft to three of the fecond, and it will receive a colour very nearly fcarlet. This may be made to receive more body by a farther flight immerfion in the mordant, and a fecond dying in the bath; and if afterward a little of the red colouring matter of the fafflower be fuperadded in the ufual way, a good fcarlet may be produced. By omitting the bark and dying the filk (prepared as before) with cochineal only, a very lively rofe colour will be produced, and this may be yellowed fo as nearly to approach the fcarlet, by a large addition of tartar to the cochineal in the dying veffel.

With lime-water as a mordant cochineal gave to filk a very agreeable purple; with muriat of barytes, a lively delicate lilac colour; with murio-fulphat of bifmuth, a falmon colour; with nitrat of cobalt, a very lively and beautiful purple; and with nearly all the other metallic and earthy bafes, cochineal produced fimilar but paler colours on filk than on wool.

Cotton. 4. On cotton. It appears that animal colouring parts have much greater attraction for the fibres of animal ftuffs than for thofe of the vegetable kingdom; hence the fmall affinity the colouring matter of the cochineal has for cotton, and it is the fame with the other animal colours. It is owing to this weaker attraction that the fcarlet dye is fo much lefs permanent on cotton than on wool; that the firft takes it more flowly, and that it is

much paler than the ſecond; and it is alſo from this want of ſufficient attraction, that the colouring matter of the cochineal is found to act moſt beneficially on cotton, when the baſis has been *firſt applied ſeparately*.

The method of dyeing cotton ſcarlet, recommended by Dr. Bancroft, is to ſoak the cotton (previouſly moiſtened) for half an hour in a diluted murio-ſulphuric ſolution of tin, as propoſed for ſilk; the ſuperfluous part of the ſolution is to be wrung out, the cotton then to be plunged in water, in which as much clean potaſh has been diſſolved as will neutralize the acid ſtill adhering to the cotton, by which the oxyd of tin will be ſet free, and more copiouſly depoſited or fixed in or upon the fibres of the cotton, which being afterwards rinſed in clean water, may be dyed with cochineal and quercitron bark, about four pounds of the former to two and a half or three pounds of the latter. By this means a full bright colour may be given to the cotton, which will bear a few ſlight waſhings with ſoap, and a conſiderable degree of expoſure to the air.

Cochineal will give cotton, previouſly impregnated with the aluminous mordant, a very beautiful crimſon colour, capable of bearing ſeveral waſhings, and of reſiſting the weather for ſome time, though not long enough to deſerve being called a faſt colour.

This chemiſt found that a ſtrong decoction of cochineal, thickened with gum, and mixed with a ſuitable proportion of nitrat of alumine, being penciled upon cotton as a proſubſtantive colour, afforded a very full beautiful crimſon, which ſtood ſome waſhings, and a conſiderable degree of expoſure to the weather.

Several of the different ſolutions of tin being employed, inſtead of the nitrat of alumine, produced very beautiful reds, between the crimſon and ſcarlet, and by a ſmall proportion of quercitron bark they were made ſcarlet.

These are not fast colours, but are much more lasting than some of the fugitive colours too often made use of.

Carmine. Carmine was formerly prepared from kermes, from which it takes it's name; it is now the lake obtained from cochineal by means of alum; a certain proportion of *autour* is mixed with the cochineal, a bark brought from the Levant, and of a paler colour than cinnamon; some *chorcan* is likewise generally added, which is a yellowish green seed of an unknown plant, growing also in the Levant. It appears to Berthollet, that in this process these two substances produce with the alum a yellow precipitate, which serves to brighten the colour of the cochineal lake, in the same manner as a yellow colouring matter serves to give scarlet a fine colour.

Kermes.

2. COCCUS ILICIS OR KERMES.

It's antiquity. THIS appears to be the species of coccus that was used by all the nations of antiquity, and professor Tychsen even conceives that it it was known to Moses under the name of tola. It was then employed for giving the ground to cloths intended to be dyed with the rich purple. It was know nto the Greeks and Romans by the name of coccum squarlatinum, coccus baphicus, infectorius, granum tinctorium; and the preference was given to that collected in Galatia and Armenia. It therefore appears to have been one of the most ancient of all dying drugs, and that which produced the colour called coccus by the Romans, and originally known in England by the name of scarlet.

It's etymology. With respect to it's etymology, according to father Plumier, it arises from the Arabic word kermen or kermez, which signifies a little worm, and is the name of this in-

fect. From it's Latin appellation coccus arofe the Spanifh diminutive coccinella, cochineal, and from it's Arabic name arofe the colour cramoufi, in French crimfon. In the middle ages it was called vermiculum, whence vermeil and vermilion, although now applied to pulverized cinnabar. Aftruc derives it from two Celtic words fignifying *oak* and *acorn*.

The kermes is an infect found in feveral parts of Afia, in the Levant, Spain, France, and other fouthern countries of Europe. It is now chiefly collected in Languedoc, Spain and Portugal. It lives on a fmall fpecies of oak called the quercus coccifera by Linneus, or the holm oak. The female having no wings, fixes herfelf amongft the leaves of this tree, where the male comes to impregnate her. Having become big, fhe gets fluggifh and remains motionlefs, brings forth and dies. In the pregnant ftate fhe foon lofes the form of an infect, and appears like a fmall roundifh grain, about the fize of a pea, of a reddifh brown colour, refembling a brown red cap, in which are enclofed a very great quantity of eggs of a deeper red colour.

Whence collected.

From the form of this infect, the kermes was for a long time taken for the feed, or an excrefcence of the tree on which it lived, and they were called grains of kermes. It appears that Pliny was of this opinion, that it was an excrefcence, although he mentions it as fpeedily becoming a worm; "coccum ilicis celerrimè in vermiculum fe mutans." The Roman natural hiftorian, indeed, inaccurately defcribes it's colour to be a fpecies of rofe, whereas in fact it is a red, approaching nearly to that of florid arterial blood.

The firft who has fpoken of this infect with any exactitude is Peter de Quinqueran, bifhop of Senez, in a work entitled, de Laudibus Provinciæ, publifhed in 1550. It's hiftory may be likewife feen written by Niffole, in the Memoirs of Acad. des Sciences for 1714,

and more particularly in the Mémoires des Infectes de Reaumur, tom. iv.

The kermes is fixed to the bark of the ſhrub by a cottony down, the production of the infect. Chaptal has obſerved that this down, as well as that afforded by all other inſects of this genus, poſſeſſes ſeveral characters of the caoutchouc or Indian rubber, that it is inſoluble in alcohol, that it melts at a boiling heat, and that it burns on the coals with a flame. According to the manner of collecting this inſect, we are informed by Bertholiet, to whom Chaptal ſent the account, that a ſingle perſon is able to gather one or two pounds per day. They begin to collect towards the middle of the month of May, when the inſect has attained it's ordinary ſize, and the harveſt continues to the middle of June, and ſometimes longer. They are generally collected by women. At the beginning, from the juice of the freſh kermes weighing heavier than at the end when it is drier and light, it only ſells for 15 or 20 ſous per pound, whilſt when the harveſt is nearly over it fetches from 30 to 40. Thoſe who buy it are obliged as ſoon as poſſible to prevent the hatching of the eggs. In order therefore to deſtroy the young, they ſteep the kermes for 10 or 12 hours in vinegar, or expoſe it to the vapours, which only takes up half an hour; it is then dried on linen cloths. This proceſs gives it a vinous red colour.

It's properties in dying.

According to Lewis and Berthollet, freſh kermes, or the living inſect, by expreſſion affords a red juice, which has rather an agreeable odour, and a ſomewhat bitter, rough, and pungent taſte. In it's dried ſtate, it imparts the ſame odour and flavour to watery and ſpirituous liquors, to which it communicates it's deep red colour. The extracts obtained from theſe tinctures by inſpiſſation retain their colour and loſe very little of their ſavour, but the aqueous extract loſes all it's ſmell. The

mordants for this colouring matter of kermes are alum and tartar; in order to prepare the wool for the kermes dye, it is to be boiled in water with about one fifth it's weight of alum, and half as much tartar, for two hours, and then left in the same liquor four or five days, when being rinsed, it is dyed in the usual way with about 12 ounces of kermes for every pound of wool. These scarlets were called *grain colours*, from the insect being mistaken for a grain; and Venice scarlet, from being principally manufactured at Venice. Wool prepared with a nitro-muriatic solution of tin (as is done for the cochineal scarlet) and dyed with kermes, takes a kind of aurora or reddish orange colour.

Compared with cochineal.

The red colour that kermes communicates to wool has less splendour than the scarlet of the cochineal, which last has been generally preferred to it, since the art has been known of using the solution of tin; but although the kermes red or scarlet is less vivid, it is more durable than that of cochineal, and much less liable to be changed by soap, acid, mud, &c. hence grease spots may be effaced without changing it. The fine blood reds seen at this time on old tapestries, in different parts of Europe, as for instance, those at Brussels, observed by Hellot, and at the other manufactories of Flanders, were all dyed from kermes, with the aluminous basis, on woollen yarn, and they are still unfaded, having scarcely lost any of their liveliness, although many of them have stood between two and three hundred years. From the solidity of this dye, it is to be regretted that it is abandoned by the dyers; some, indeed, mix a small quantity of it with the cochineal, as it gives a greater body to the colour; but it diminishes it's bloom.

According to Berthollet, the colour produced by half kermes and half madder is called scarlet in half grain. This mixture affords a very permanent dye, but is not

lively, and inclines a little to the blood red. The turbans manufactured at Orleans, for the Levant, are ſaid to be dyed in this manner, although a little Braſil wood is probably added.

Dyers have only been able to give ſilk, with kermes, a dull reddiſh colour.

According to Bancroft, cotton prepared with the aluminous mordant, and dyed with kermes, exhibits a fine red, inclining to the crimſon ſhade; but this will gradually though ſlowly diſcharge, and the colour be weakened in waſhing. This chemiſt is in hopes of ſucceeding in fixing the colour of kermes more permanently on cotton.

Lac.

3. COCCUS LACCA.

GUM LAC, as it is improperly called, is a ſpecies of wax which forms the cells of a certain inſect called coccus lacca by Linnæus, and the beautiful red colour is owing to the inſect; if, however, the inſect has left it, which it does by piercing a hole at the top of the cell, the lac is no longer of that red colour, is of no uſe in dying, and is only employed for varniſhes. The inſect is an inhabitant of the Eaſt Indies, inhabiting, according to Ker, the uncultivated mountains on both ſides of the Ganges, where it is produced in ſuch abundance, that was the conſumption ten times greater than it is, the markets might be well ſupplied by this minute inſect. The price at Dacca is about twelve ſhillings the hundred pound, although it is brought from the diſtant country of Aſſam.

Whence brought.

This author informs us, that this inſect, in the country

where he was, is found on four ſpecies of ſhrubs, viz. on the ficus religioſa Lin. the ficus indica Lin. the plaſo Hortus Malabaraci, and the rhammus jujuba Lin.

The inſects of this ſpecies fix themſelves in ſuch multitudes on the branches of theſe trees, and more eſpecially on the three firſt, that the extreme branches appear as if they were covered with a red duſt that deſtroys both trees and fruit. Birds perching on theſe branches likewiſe carry off great numbers of the lacca inſects adhering to their feet, and thus tranſplant them, by depoſiting them on other trees where they reſt. Of theſe four ſpecies of trees, it appears, there is only one, the rhammus jujuba, upon which Dr. James Anderſon found theſe inſects near Madras, although he obſerved them on ſeveral ſpecies of mimoſa, and on ſome other trees and ſhrubs. Dr. Roxburgh of Samulcotta, however, ſeems to think, that on the coaſt of Coromandel they only inhabit ſhrubs of the mimoſa kind, and even but three ſpecies of this genus. This laſt gentleman has given a deſcription of the nature and progreſs of theſe inſects, with great minuteneſs, in the Philoſoph. Tranſ. for 1791. The gum lac is diſtinguiſhed by ſeveral names: thus, in it's moſt natural ſtate, or adhering externally to the ſmall branches of the ſhrub, it is called *ſtick lac*; when it is detached from theſe and reduced to a groſs kind of powder, *red lac*; when liquified and made into cakes, *lump lac*; and when the ſeed lac is deprived of it's colouring matter, and formed into thin tranſparent plates, it is called *ſhell lac*. Dr. Roxburgh is of opinion, that the colour ſhould be extracted from freſh lac inſtead of dry lac, in the month of October, or beginning of November, before the inſects have acquired life, as he found the deepeſt and beſt colour to be produced from the eggs when mixed with the

It's varieties.

nidus, whilſt the dried lac communicates a much leſs bright colour to water.

Bancroft's method of extracting the colour from it.

According to Bancroft, the colouring matter may be got from this drug in the form of extract, by boiling it in water, then by filtration and evaporation.

Compared with cochineal.

The colours dyed by *Stick lac* approach very nearly to thoſe of cochineal. They are not quite ſo lively and beautiful; but this defect is in ſome meaſure compenſated by their being more durable, eſpecially on cottons. It requires the ſame baſis and treatment as cochineal. It is uſed by the natives of India as a dye; and according to Sir William Jones, the Hindus have ſix names for lac, although they generally call it lácſha, from the multitude of ſmall inſects, which they believe diſcharge it from their ſtomach, and at length deſtroy the tree on which they form their colonies. It was likewiſe in uſe as a dye amongſt the ancients. The moderns uſe it as the baſis of ſealing wax; and the greater part that comes to Europe is afterwards ſent to Portugal, Barbary, &c. where it is employed in ſtaining goatſkins to make what is called red Morocco leather.

Uſed in ſealing wax.

Examined chemically.

Neuman looked upon gum lac as a very hard ſort of wax, tinctured with an animal red, of the cochineal kind; he found, that the ſeed lac does not diſſolve in water or in oils. To alum water it afforded a beautiful tranſparent red. Dr. Bancroft likewiſe found the colouring matter he received from the Eaſt Indies, which moſt probably was of this ſpecies, to be inſoluble in water, which he attributes to it's being too intimately united to a portion of alumine, employed in India to precipitate it, as a little pearl aſh brought about it's ſolubility. Neuman found, that of the concentrated acids, the vitriolic extracted very little of it, the marine ſomewhat more, and the nitrous nothing. Spirit of wine, after ſome time, diſ-

folved nearly the whole of it, and the folution was of a brown colour. Diftilled in the open fire, a thick empyreumatic oil was obtained, fimilar to that of common wax, after which arofe an aqueous liquor, not manifeftly acid, or alkaline. There remained a refiduum.

Fourcroy looks upon it as a true wax, although he thinks it's drynefs, the aromatic odour it exhales in burning, and it's folubility in fpirit of wine, indicate a refemblance between it and the refins. By diftillation, he found it afforded a kind of butter.

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4. COCCUS POLONICUS.

THE coccus tinctorius polonicus, as it is called, is a fmall round infect, about the fize of a coriander feed, of a purple brown colour on the outfide, and full of a blood red juice, which has been ufed in dying. It is collected in confiderable quantities in wafte fandy grounds in the Ukraine, and other provinces of Poland, and in the great duchy of Lithuania, where it is found adhering to the roots of the German knot grafs or knawel (fcleranthus perennis.) It is gathered towards the end of June. It appears to have properties refembling thofe of kermes, but fince the cheaper and more beautiful colours of cochineal have become generally known, it has been laid afide as well as the kermes. It was formerly very much ufed by the Turks and Armenians to dye wool, filk and hair, as well as in the ftaining the nails of women's fingers. This colouring matter was fixed on wool and filk by the ufual mordant or preparation of alum and tartar.

Coccus polonicus.

Where collected.

Compared with kermes.

Nearly refembling the coccus polonicus is an infect which in many parts of Europe was formerly taken from

Other infects ufed in dying.

the roots of the burnet, (poterium ſanguiſorba, Lin.) and uſed in different countries, particularly by the Moors, for dying ſilk and wool of a crimſon or roſe colour. To this may be added the coccus uvæ urſi, Lin. which is likewiſe an inſect affording a fine red colour, and it has the advantage of being nearly twice the ſize of the polonicus.

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—Obſerv. ſur la Phoſphore des vers luiſans, &c. par id. id. T. 34. p. 187. an. 8.—Exper. et obſerv. ſur la Phoſphoreſcence de Lucioles, Lampyris Italica par id. id. T. 26. p. 96. 1798.—Sur quelques Modifications de la Lumière, par le Cit. Brugnatelli, id. p. 107.

CONCRETIONS.

Animal concretions.

In this clafs of animal fubftances are comprehended all thofe more or lefs folid concretions which are formed in the different parts of animals, and which, as they are generally found either in the refervoirs or ducts of the different fecretions or excretions, are fuppofed to originate in confequence of the fluids being fecreted in a difeafed ftate. The advantages that may arife from the analyfis of fuch fubftances are expected to be,

The ufe of their analyfis.

1. To afford the phyfiologift a more accurate knowledge of the animal mechanifm, by fhowing him the principles upon which they are formed, and the circumftances that give rife to them.

2. To affift in that inveftigation which is neceffary to arrive at the cure of the difeafes they produce, and often attended with the greateft danger.

For the beft analyfis of many of the fubftances of this clafs we are principally indebted to the labours of Scheele, who firft thoroughly inveftigated one fpecies of calculus; to Fourcroy, to whofe fkill in this part of fcience animal chemiftry owes fo much, and to Drs. Woollafton and Pearfon.

CALCULUS VESICÆ, OR STONE OF THE BLADDER.

Of all the hollow vifcera, it is the human bladder in which calculous concretions are the moft frequently and abundantly found, and according to Fourcroy, it is a remarkable fact, that they differ more by their volume,

their weight, their form, and their colour, than by their component parts, as appears from the reſult of all the experiments of modern chemiſts on this ſubject. With reſpect to their external properties, we are informed by Baillie, that when there is only one calculus preſent in the bladder, it is uſually of an oval form, but when there are more, as is generally the caſe, they acquire by friction flat ſides and angles. The veſical calculi have ſometimes a ſmooth uniform ſurface, but more frequently granulated, ſo that they appear more or leſs rough; ſome have an irregular porous ſtructure on the ſurface, inſtead of being granulated. When divided by the ſaw or broken, they exhibited moſt commonly a luminated ſtructure. Theſe laminæ are diſpoſed in concentric curves, and are applied together with more or leſs compactneſs, and they differ in thickneſs in different calculi. The laminated ſtructure ſometimes pervades uniformly the whole maſs of the calculus, at other times, different portions of it are interrupted by a coarſe porous texture. In ſome calculi there is no laminated ſtrata, but they are entirely porous. Their colour varies conſiderably; they are moſt frequently of a brown colour, of a lighter or darker ſhade, ſometimes they are white, ſometimes of a yellowiſh colour, and different portions of the ſame calculus are frequently of a different colour; ſome laminæ, for inſtance, are perfectly white, while the others are brown; in this ſort of mixture Baillie has moſt commonly found the white laminæ on the outſide, and the brown in the middle, nor does he recollect ſeeing one inſtance of laminæ of different colours diſpoſed in alternate ſtrata. Although the matter of the calculus is generally formed into one or more circumſcribed maſſes, yet it ſometimes happens that the whole bladder is filled with a ſubſtance like mortar.

External properties.

If we afcend to antiquity for the ideas entertained on the calculi of the bladder, we fhall find, that the ancients looked upon them as mere ftone or gravel, judging of them according to their external refemblance; hence this calculus was called by Aretæus, and Aurelianus, among the Greeks, λιθος and λιθιασις; by Celfus and Pliny, among the Latins, calculus and fabulum. Indeed it was fuppofed by Galen, that a vifcid animal matter was the bafis of thefe concretions; but in his days, earth was looked upon to be the bafis of all animal matter; the Greek phyficians, however, employed alcalis to cure thefe difeafes.

Opinion of the ancients.

On defcending to more modern times, we find that the ideas of phyficians refpecting thefe fubftances, although they differed, were far from the truth; thus Bafil Valentine looked upon them to be tartar, and Paracelfus, as intermediate fubftances between tartar and ftone, of which the animal refin formed the firft matter; and he admitted of no difference between the calculi of the bladder, which he called by the barbarous name of *dueleck*, and arthritic or gouty concretions, except that the firft was hardened by the fpirit of the urine, whilft the laft contained more falt.

Paracelfus.

Van Helmont.

Van Helmont, after having commented a long time on this matter, concluded the *dueleck* to be an anomalous coagulum, arifing from the falts of the urine, and an earthy volatile fpirit, without any vifcous or mucilaginous matter, and without any progreffive induration, whilft the arthritic chalk, on the contrary, was the production of the induration of the fynovia of the articulations, and the flow acidification of this vifcid fubftance. On diftilling this dueleck, by the dry way, he obtained a volatile alkaline fpirit, a yellow cryftallized mafs depofited in the neck of the retort, a little empyreumatic oil, and a taftelefs pulverizable coal.

Boyle found this calculus to be compofed of oil and a great quantity of volatile falt; Boerhaave fuppofed it to be a fubtile earth, intimately united to volatile alkaline falts. Slare and Hales had obferved nearly the fame products as Van Helmont; but Hales, on diftilling a calculus by a pneumatic apparatus, found, that it afforded 645 times it's volume (it weighed 230 grains) of an aeriform fluid, and that there only remained a refidue, weighing 49 grains; hence he looked upon it to be fimilar to tartar, which likewife affords a confiderable quantity of gas, and he concluded that the calculus was an animal tartar. Boyle.

The decompofition of this fubftance was alfo attempted by other chemifts, as Hoffmann, Pott, Geoffroy, Rutty, Palucci, &c. But fo little was the progrefs they had made in the inveftigation of this concretion, that any defcription would be unneceffary; a detail of their labours may be found in Haller. Hoffmann.

Some phyficians had likewife attempted to decompofe it in the body, by various medicines, known by the name of lithontriptics. Amongft thefe were Alfton, Whitt, Butter, and de Haen; they had made fome experiments on the lithontriptic virtue of foap, of limewater, and of alkalies; the alkaline preparation known by the name of *fixed nitre* was particularly recommended by Vogel and Meckel; and the lithontriptic of Turin was underftood to be the cauftic foda or ley of the foap boilers; however, the more general opinion was at that time, that acids were the true diffolvents of this calculus, and that it contained a foluble earth, or an animal earth, perfectly analogous to that of bones. Attempts to decompofe it in the body.

It was from the imperfection of the analyfis of this fubftance, that the idea of it's being ftony was entertained, till not many years ago; and although, as it appears, the experiments of Slare and Hales, as well as a few others, had before fhown that thefe calculi commonly

consist of animal matter; this opinion was not generally received. As to the earth of which they were supposed to be composed, it is well known, the only distinction between earths, till about forty years ago, was into absolvent and nonabsolvent, and as the absolvent earths were divided into the calcareous, magnesia, and clay, the calcareous was considered as that existing in urinary concretions, most probably from it's being so extensively diffused through the whole animal kingdom. With respect to it's being the earth of bones, the experiments of Margraaf proved the futility of the analogy.

Supposed to be calcareous.

Such were the ideas entertained of this substance before the experiments of Scheele; it was known that the matter of which it is composed exists more or less abundantly in urine, but the conjectures respecting it's nature were totally false, till this celebrated chemist proved it to be an acid, now known by the name of the lithic acid.

The experiments of Scheele were published in Sweden in the year 1776; and as Bergman had undertaken, much about the same time, an investigation of it, whose steps have been followed by several other chemists, some short account will be indispensable.

Distillation.

According to Scheele, this calculus afforded, on distillation, a volatile alkaline spirit, a brown sublimate, which became white on repeating the operation, and mixed with alkalis, gave no smell, but an acid taste, was soluble in boiling water and alcohol, did not precipitate lime from it's solution, and appeared to resemble, in some measure, the salt of amber; and there remained a black coal which preserved it's colour on red-hot iron. From 70 grains of calculus he obtained 28 grains of the sublimate, which is the concrete volatile lithic acid, and 12 grains of coal.

These experiments, it may be observed, resemble those

of Margraaff. From 1 ounce and a quarter of calculus, he obtained 2 drachms and a half of a ſublimate, which, on rectification, afforded a little volatile alkaline ſpirit, and a white ſublimate; but the fire being increaſed, a thick yellow acid oil. The white ſublimate was for the moſt part ſoluble in water, and the evaporated ſolution depoſited a triple ſalt, viz. a taſteleſs, a ſweet, and a bitter one, each of which diſtilled with fixed vegetable alcali gave a little volatile alcali, the reſiduum appearing to him to ſhow a trace of fuſible ſalt of urine.

Hartenkeil obtained from one ounce of calculus 355 cubic inches of aerial matter, of which 301 were fixed air, and of the remainder one fourth was taken up by an equal quantity of nitrous air. He then got four drachms and nine grains of an empyreumatic oil, 55 grains of volatile alkaline ſpirit, and two drachms 33 grains of coal, which, on calcination, was nearly all conſumed. Scopoli obtained from 25 grains of calculus the ſame number of cubic inches of fixed air.

Nicholas Tychſen, beſides a little air, obtained a brown inflammable ſublimate, dry volatile alkali, a little fluid reſembling ſpirit of hartſhorn, and a coal, $\frac{1}{16}$ part of which was inſoluble in muriatic acid.

Linke obtained in a ſtrong diſtilling heat a yellow fluid like ſpirit of hartſhorn, volatile alkali, a few drops of an empyreumatic oil, and a black ſhining coal; and Titius got fixed air, volatile alkali, an empyreumatic oil, a brown ſublimate, and a very black coal containing calcareous earth.

Frederic Hoffmann, Margraaff, and Hartenkeil, ſaw the calculus when expoſed to the open fire, as well as Tychſen, before the blowpipe, become at firſt black, but afterwards with an evident volatile alkaline and empyreumatic ſmell, without any peculiar ſmoke, until it was conſumed to a more or leſs trifling white or darkiſh reſidue,

Water.

From Scheele's experiments the calculus is perfectly soluble in water. Five ounces of boiling water dissolved eight grains. This solution changed the tincture of litmus to a red, did not precipitate lime from it's water, and on becoming cool, deposited the greatest part of the dissolved calculus in the form of fine crystals. Margraaf also found it soluble in water.

Frederic Hoffmann only obtained by boiling calculus in water a white turbid solution, which, on being exsiccated, left a whitish matter of a bitter saline taste, gave no empyreumatic alkaline smell on hot coals, as was the case with the calculus, and the remaining powder showed no trace of volatile alkali on levigation with potash and did not effervesce with vitriolic acid.

Bergmann likewise could not obtain a perfect solution of this calculus in boiling water, but observed some white spongy particles to separate, that were neither acted upon by water, alcohol, acids, nor caustic volatile alkali, and which exposed to the fire, afforded a coal difficult of incineration, the ashes of which were insoluble in nitrous acid; but he procured it in such small quantity as not to be able to examine it.

The experiments of Hartenkeil confirm those of Bergmann, who observed, that out of two drachms of calculus kept in six ounces of distilled water during four days, only two grains were dissolved, and only five by a boiling heat; whilst Tychsen could dissolve none either in cold or boiling water; and Linke, who, on boiling the softened rind of calculus in 16 times it's quantity of water, found the small quantity dissolved to be only gelatinous.

Vitriolic acid.

The vitriolic acid, according to Scheele, only dissolved the calculus when concentrated, and by the assistance of heat, during which operation he found the acid to arise in it's phlogisticated state. He found the muriatic acid had no effect upon it even at a boiling heat. Hales,

Muriatic acid.

Margraaf, and Tychfen have obferved, however, fome flight degree of folution, according to the laft, it communicated to this acid a bitter tafte, when digefted with it in a concentrated ftate; and Baillie met with one that was foluble in this acid at the common temperature of the air.

Nitrous acid.

The fame chemift informs us, that the nitrous acid attacked it even in the cold, that by the aid of heat it was entirely diffolved, fending forth red vapours. Margraaf, Hartenkeil, and Bergman, however, found a fmall refidue, confifting of white fpongy flocks, refembling thofe obtained by boiling in water. The folution was yellow.

If this procefs was performed in a retort, Scheele found, that the gas which arofe precipitated limewater in the receiver; this proceeded from the fixed air, as Hales remarked, that a great quantity of it was always prefent in the calculus. The folution always tafted four, even after faturation, although Bergman obferved no fmell of the nitrous acid; this fhowed the prefence of a free acid. It coloured the fkin, bones, glafs, paper, after fome time, of a beautiful red colour. If evaporated to concentration, it appeared as red as blood, but this colour difappeared on the addition of a few drops of nitrous acid, and was not to be recalled by alkalis or any other means. By a quicker evaporation, this high red liquor was converted into numberlefs bladders, and at laft a dark red fcum, which, on exficcation, appeared of a black red, and which, on folution in water, gave it a beautiful rofe colour, and was diffolved by all acids and cauftic alcalis, with a lofs of it's colour, although it remained longer with the laft. Expofed to the air, this dried red mafs feemed inclined to deliquefcence. The nitrous folution was not precipitated by the muriat of barytes, which would have been the cafe if it had contained the vitriolic acid, from which fuppofition the

calculus had been looked upon as of a gypſeous nature; nor was it changed by metallic ſolutions; by the addition of a fixed alkali it's colour was only turned yellow, and when the alkali was abundant, the mixture, on digeſtion, became of a roſe colour, which was immediately communicated to the ſkin; in this ſtate it precipitated metals from their ſolutions, of different colours; the vitriol of iron black; vitriol of copper green; ſilver gray; corroſive muriat of mercury, zinc, and lead, white. Limewater decompoſed the nitrous ſolution, and produced a white precipitate, which precipitate, after having been well edulcorated and dried, was ſoluble in the nitrous and muriatic acids, without efferveſcence. This circumſtance proves it could not be calcareous. Even after the ſuperſaturation of theſe acids with the precipitate, the ſolution taſted ſour, and inflamed on being evaporated to dryneſs; on calcining this precipitate in cloſed veſſels, it left a ſpungy black matter reſembling calcined alum; and in this ſtate it efferveſced with acids, and expoſed to the blowpipe, was converted into quicklime. By the addition of oxalic acid, the nitrous ſolution was not affected either before or after it's mixture with alcalis, from which it appears that no calcareous earth was preſent in the calculus.

Bergman tries to find calcareous earth.

Bergman endeavoured to diſcover calcareous earth in this ſubſtance, by other means: firſt, he incinerated the coal of the calculus, and found that the white aſhes efferveſced a little with acids; that they formed gypſum with the vitriolic; that they were ſoluble in the nitrous even to $\frac{1}{100}$, and alſo a part, which he looked upon as calcareous, ſoluble in pure water. Secondly, by exſiccation of the nitrous ſolution of calculus, and incinerating the dried reſiduum, he obtained a calcareous powder. Thirdly, he obſerved that the vitriolic acid, on being mixed with the diluted nitrous ſolution, produced no change; but on

adding it to a ſtrong nitrous ſolution, or to the diluted when concentrated by evaporation, ſome ſmall cryſtals were produced, which were ſoluble in diſtilled water, gave a precipitate with oxalic acid, and poſſeſſed all the properties of gypſum. Although theſe experiments prove beyond all doubt the exiſtence of this earth in calculus, yet it exiſts in ſo inconſiderable a quantity, as rarely to exceed $\frac{1}{200}$; and hence the cauſe that moſt chemiſts on the calcination of theſe ſubſtances find an extremely inconſiderable quantity of aſhes. According to Pechlin, the nitrous acid which ſo forcibly diſſolves the calculus when pure, poſſeſſes this property when dulcified with alcohol; Hartenkeil, however, found this menſtruum ſo weak in it's action, that ſix ounces of it only diſſolved three grains of calculus.

Vinegar likewiſe diſſolves calculus; thus Margraaf found, that one ounce of diſtilled vinegar took up one grain of it. Vinegar.

According to Tychſen, the citric acid is more active on this ſubſtance than diſtilled vinegar. Citric acid.

From Margraaf's experiments, the formic acid had very little, and the phoſphoric no effect. Formic and phoſphoric acids.

Lobb, by a continued digeſtion of calculus with the following ſubſtances, found it to be rendered partly more ſoft, and partly diſſolved, viz. with lemon juice, vinegar, the expreſſed juices of radiſh, aſparagus, ſorrel, parſley, onions, oranges, mulberries, potatoes, pears, grapes and pumions; alſo with milk and different kinds of wine. Lemon juice, &c.

According to Scheele, 1000 grains of limewater diſſolved, on digeſtion, 5,37 of calculus, which were again precipitated by acids, at leaſt in part. Lime water.

This property of limewater had been before obſerved by Baſil Valentine; but Hartenkeil and Tychſen found it's action to be very ſmall. It was this, however, which was ſo long recommended as a lithontriptic, particularly

by Robert Whytt; and the ſoap compoſed of the lime of all ſhell fiſh formed Stevens's celebrated medicine.

Alkalis. Scheele found, that mild alkalis had no action upon calculis, but was diſſolved by them in their cauſtic ſtate, even in the cold. The ſolution in cauſtic potaſh was yellow, of a ſweetiſh taſte, did not render limewater turbid, was precipitated by all acids, even by the carbonic, and decompoſed metallic ſolutions, viz. iron, of a brown colour; copper, gray; ſilver, black; and zinc, lead, and corroſive ſublimate, white; if too much alkali was employed, it produced an ammoniacal odour; with reſpect to cauſtic volatile alkali, a large proportion was neceſſary for a ſolution.

Carbonated water. It alſo appears, that water containing fixed air poſſeſſes a menſtrual action on this ſubſtance. This was obſerved by Springsfeld, of the water at Karlſbad, and by Falconer, Saunders, and Percival, of water artificially impregnated; but with reſpect to the laſt it is ſo weak and inſignificant as not to be eſteemed better than common water in curing the diſeaſe.

Scheele and Bergman. From their experiments, Scheele and Bergman have concluded, that the veſical calculus is an oily, concrete, volatile acid, united to a gelatinous part: that it's ſaline nature is proved by it's ſolubility in water; it's acidity, from the reddening of the tincture of litmus by this ſolution, and from it's union with alkaline ſalts, as well as with limewater, the cauſtic taſte of which it moderates: that the difference between this acid and fixed air is known by it's not rendering limewater turbid: that it's inflammable nature is evident from the quantity of red vapours which ariſe during it's ſolution in the nitrous acid, and the red colour extricated from it by that acid. Finally, that it's volatility appears from the ſublimate obtained by the diſtillation of the calculus. Scopoli and Titus have obtained the oxalic acid from this ſubſtance.

According to Morveau, the experiments of Scheele and Bergman prefent feveral important confequences. With refpect to the compofition of calculus, he alleges, that volatile alcali certainly forms a part of it, although the fmalleft, whilft the lithic acid compofes the greateft. Scheele admits an animal gelatinous matter in it; and Morveau concludes, that it contains an oil, or mucilaginous oil, capable of furnifhing phlogifton; he grounds this affertion on the fmoaking vapours it gives with the nitrous acid; it however appears to this chemift, that it's quality perhaps cannot be afcertained by the coaly refiduum found in the retort after diftillation, for that the lofs of $\frac{3}{7}$ of the weight of the whole, verified by it's comparifon with the fum of all the products, announces a decompofition of a confiderable part of the acid, a portion of which converted into mephitic acid he thinks has produced with the phlogifton a real plumbago, which is detected by it's refiftence to incineration. Morveau.

From the nitrous folution not being rendered turbid by the oxalic acid, Scheele concluded, that not an atom of calcareous earth was prefent in the calculus, and this proof is looked upon as very correct by Bergman, although he acknowledges it may fometimes fail; as when the oxalic acid, inftead of precipitating calcareous earth, forms with it a triple falt: he, however, found, as above mentioned, a very inconfiderable quantity in a calculus of the kidney. It may hence be feen how far they were erroneous who fo long believed that the calculus of the bladder was a calcareous concretion, or at leaft of the nature of the earth of bones; and the inutility of their attempts to prevent it's formation, or to effect it's folution is now no longer furprifing; Bergman having well obferved, that every refearch for the cure of this difeafe ought to be founded on the perfect knowledge of the properties of the calculus itfelf. To conclude, it appears

from these experiments, that the calculi of the bladder are for the most part composed of this acid, called by Morveau, the lithic acid; that all which this last chemist has examined, and which have been very numerous, were found to be of the same nature, as well as those analyzed by Scheele and Bergman, although it may happen that a different species may be accidentally met with. Thus

Tennant. it appears from a letter to Morveau, written by Tennant, of the Royal Society of London, that in his experiments on the vesical calculi, he found some that only lost, on calcination, $\frac{2}{3}$ of their weight; that the residuum, forming a transparent glass, on cooling became white. To judge of them by these facts, they ought, according to Morveau, to contain a pretty considerable quantity of phosphat of lime, with a superabundance of acid.

Scheele found, that more or less calculous matter was present in all urine, even in that of infants; that the brick-coloured deposit to be seen in the urine of patients under fever was of the same nature, that it separated by cooling alone, and that it might be redissolved by the assistance of a sufficient degree of heat.

After Bergman and Scheele had investigated the nature of the calculous matter; the next author of any con-

Fourcroy. sequence was Fourcroy; he examined a great number of varieties, and the result of his analysis is as follows:

1. The aqueous solution of calculi reddened the dyed paper of turnsole.

2. By distillation on the fire, and by the action of the nitric acid, they afford prussic acid. At first there arises a colourless liquor, then some elastic fluids, composed of carbonic acid, of hydrogen gas, and a little azot. In the neck of the retort he found some brilliant, lamellated, and more or less yellow crystals of pure lithic acid, and a small quantity of carbonat of ammonia; there remained in the retort a great quantity of coal; he obtained no

oil. On examining the liquid product, the odour of free pruffic acid was to be recognized. In the water a fmall quantity of carbonat of ammonia and pruffiat of ammonia were found. The prefence of the pruffic acid was eafily diftinguifhed by the oxyd of iron newly precipitated, which was converted into Pruffian blue on cafting it into this liquor.

3. From thefe facts Fourcroy concludes, that the vefical calculus contains but a very fmall portion of hydrogen, as a very little ammonia is formed; that a great quantity of azot is difengaged, but no oil; that the lithic acid contains but a very fmall quantity of oxygen, very little of the pruffic and carbonic acids being formed; and befides, from there remaining in the retort a very large quantity of coal.

4. From thefe obfervations he likewife infers, that the pruffic acid contains more oxygen than the lithic acid, fince there is only very little pruffic acid formed from the decompofition of a great quantity of lithic acid; that probably carbonic acid is formed at the fame time, but in fmall quantity in comparifon to the mafs of coal remaining in the retort.

This chemift admits that thefe general confiderations are not fufficient to explain the phenomena which the analyfis of the vefical calculi prefent; he has therefore added a detail of his experiments made in 1787, which, although they are far from rendering the fubject complete, may throw further light on their decompofition.

Thefe were made upon four kinds of calculi, and fhow a great analogy to thofe of Scheele, publifhed a few years before. All his truths are here attefted; the prefence likewife of fome atoms of lime, indicated by Bergman, are to be found in them; that of the phofphat of ammonia, which pretty conftantly exifts in thefe calculi, and of

the phofphat of foda, which is often to be feen cryftallized between the ftrata of the calculi. He has likewife recognized in thefe experiments the volatility of the lithic acid, it's greater folubility in warm than in cold water, and it's being capable of cryftallization by means of cold; he likewife found, that the calculus fpontaneoufly gives the pruffic acid by diftillation. The refult of the labours of this chemift are, that the only appearance of lithontriptics is in the ufe of cauftic fixed alcalis, &c. With refpect to the vefical calculi of other animals, nothing had been done refpecting their inveftigation until this chemift made a few experiments upon two; one taken from the horfe, the other from an ox, but neither of them afforded any thing analogous to the lithic acid; the products he obtained were the carbonat and phofphat of lime.

Dr. Wollafton.

The vefical calculi examined by Dr. Wollafton are the following, viz.

Experiments on the fufible calculus.

Fufible calculus. This was firft afcertained to differ from that of Scheele, by Tennant, who found, as before obferved, that inftead of being nearly confumed by the blowpipe, a large proportion of it was left fufed into an opake white glafs, which he conjectured to be phofphorated lime united with other phofphoric falts of the urine; but he never attempted a more minute analyfis. Stones of this kind, according to Dr. Wollafton, are always whiter than thofe defcribed by Scheele, and fome fpecimens are perfectly white. The greater part have an appearance of fparkling cryftals, which are moft difcernible where two crufts of a laminated ftone have been feparated from each other. Having had an opportunity of procuring thefe cryftals alone, voided in the form of a white fand, he was enabled to determine the nature of the compound ftone, in which they are cemented by other ingredients.

The cryſtals conſiſt of phoſphoric acid, magneſia, and volatile alkali; the ſtone contains alſo phoſphorated lime and generally ſome lithic acid. The form of the cryſtal is a ſhort trilateral priſm, having one angle a right angle, and the other two equal, terminated by a pyramid of three or ſix ſides. On ſubmitting them to experiment he found, that,

1. Heat drives off the volatile alkali from the cryſtals, and they are rendered opake, or may be partially fuſed. The phoſphorated magneſia may then be diſſolved in nitrous acid, and by addition of quickſilver, diſſolved in the ſame acid, a precipitate of phoſphorated quickſilver is obtained, from which the quickſilver may be expelled by heat, and the acid procured ſeparate. By addition of vitriolic acid to the remaining ſolution, Epſom ſalt is formed, and may be cryſtallized after the requiſite evaporation of the nitrous acid, and ſeparation of any redundant quickſilver.

2. Theſe cryſtals require a very large quantity of water for their ſolution, but are readily ſoluble in moſt, if not all acids, viz. vitriolic, nitrous, marine, phoſphoric, ſaccharine, and acetous; and when precipitated from them reaſſume the cryſtalline form.

3. From the ſolution in marine acid, ſal ammoniac may be obtained by ſublimation.

4. Although the analyſis is ſatisfactory, the ſynthetic proof is, if poſſible, ſtill more ſo. After diſſolving magneſia in phoſphoric acid, the addition of volatile alkali immediately forms the cryſtalline precipitate, having the ſame figure and properties as the original cryſtals.

5. If volatile alkali be cautiouſly mixed with recent urine, the ſame compound will be formed; the firſt appearance that takes place when a ſufficient quantity of alkali has been gradually added, is a precipitate of theſe triple cryſtals. Theſe conſtitute the greater part of the

fusible stone, so that a previous acquaintance with their properties is necessary, in order to comprehend justly the nature of the compound stone in which they are contained.

The most direct analysis of the compound stone is effected by the successive action of distilled vinegar, marine acid, and caustic vegetable alkali.

6. Distilled vinegar acts but slowly upon the calculus when entire; but when powdered, it immediately dissolves the triple crystals, which may be again precipitated from it as crystals by volatile alkali; and if the solution has not been aided by heat, scarcely any of the phosphorated lime will be found blended with them.

In one trial the triple crystals exceeded $\frac{6}{10}$ of the quantity employed; but it seemed unnecessary to determine the exact proportion which they bear to the other ingredients in any one instance, as that proportion must vary in different specimens of such an assemblage of substances not chemically combined.

Marine acid poured on the remainder dissolves the phosphorated lime, leaving a very small residuum.

This is soluble in caustic vegetable alkali entirely, and has every other property of mere lithic acid.

The presence of volatile alkali in the compound stone may be shown in various ways.

7. In the distillation of this stone, there arises first volatile alkali in great abundance, a little fetid oil, and lithic acid. There remains a large proportion charred. Water poured upon the remaining coal dissolves an extremely small quantity of a salt, apparently common salt, but too minute for accurate examination. Distilled vinegar dissolves no part of it, even when powdered. Marine acid dissolves the phosphorated lime and phosphorated magnesia, leaving nothing but a little charcoal. From this solution, vitriolic acid occasions a precipitate

of ſelenite, after which triple cryſtals may be formed by addition of volatile alcali.

8. Marine acid alſo acts readily upon a fragment of the ſtone, leaving only yellowiſh laminæ of lithic acid. When the ſolution has been evaporated to dryneſs, ſal ammoniac may be ſublimed from it; and the two phoſphorated earths are found combined with more or leſs of marine acid, according to the degree of heat employed. If the proportion of the earth is wiſhed to be aſcertained, acid of ſugar will ſeparate them moſt effectually, by diſſolving the phoſphorated magneſia, and forming an inſoluble compound with the lime.

9. Cauſtic vegetable alkali has but little effect upon the entire ſtone, but if heated upon the ſtone in powder, a ſtrong effervefcence takes place from the eſcape of alkaline air, and the menſtruum is found to contain lithic acid precipitable by any other acid. Some phoſphoric acid alſo, from a partial decompoſition of the triple cryſtals, is detected by nitrated quickſilver.

10. The triple cryſtals alone are ſcarcely fuſible under the blow-pipe; phoſphorated lime proves ſtill more refractory; but mixtures of the two are extremely fuſible, which explains the fuſibility of the calculus.

The appearance of the lithic ſtrata, and the ſmall proportion they bear to the other ingredients, ſhow that they are not an eſſential part, but an accidental depoſit, that would be formed on any extraneous ſubſtance in the bladder, and which probably in this inſtance concretes during any temporary interval that may occur in the formation of the cryſtals.

Mulberry calculus. This ſtone, though by no means overlooked, and though pointed out as different from other ſpecies, has not, according to Dr. Wollaſton, been ſubjected to any farther analyſis than is given by Dr. Mulberry calculus.

Dawſon, (2d vol. Med. Tranſ.) who found that his lixivium had little or no effect upon it; and by Lane, (Phil. Tranſ.) who, among other ſimple and compound ſtones, gives an account of the comparative effects of lixivium and heat upon a few ſpecimens of mulberry calculus, viz. (No. 7, 8, 9, 10;) but neither of theſe writers attempted to aſcertain the conſtituent parts.

Though the name has been confined to ſuch ſtones as, from their irregular knotted ſurface and dark colour, bear a diſtant reſemblance to that fruit, Dr. Wollaſton has found the ſpecies, chemically conſidered, to be more extenſive, comprehending ſome of the ſmootheſt ſtones to be met with, one of which in his poſſeſſion is of a much lighter colour, ſo as to reſemble in hue, as well as in ſmoothneſs, the ſurface of a hemp-ſeed. From this circumſtance it appears probable to this chemiſt, that the darkneſs of irregular ſtones may have ariſen from blood voided in conſequence of their roughneſs.

The ſmooth calculus was found to conſiſt of lime united with the acids of ſugar and of phoſphorus. The rougher ſpecimens have generally more lithic acid in their interſtices.

1. Cauſtic vegetable alcali acquires a ſlight tinge from a fragment of this kind of ſtone, but will not diſſolve it. When powdered it is thereby purified from any quantity of lithic acid that it may contain. Phoſphoric acid will then diſſolve the phoſphorated lime; and the remainder, after being waſhed, may be decompoſed by the vitriolic. The affinity of this acid for a certain proportion of lime, is ſuperior even to that of acid of ſugar; ſelenite is formed, and the acid of ſugar may be cryſtallized, and by the form of it's cryſtals recognized, as well as by every other property. It is eaſily ſoluble, occaſions a precipitate from lime water, and from a ſolution of ſelenite, and

with mineral alkali forms a ſalt that requires a large quantity of water for it's ſolution.

2. When the ſtone has been finely powdered, marine acid will ſlowly diſſolve all but any ſmall quantity of lithic matter which it may contain. After the ſolution has been evaporated to dryneſs, no part is then ſoluble in water, the marine acid being wholly expelled. When the dried maſs is diſtilled with a greater heat, the ſaccharine acid is decompoſed, and a ſublimate formed, ſtill acid and ſtill cryſtallizable, but much leſs ſoluble in water, and which does not precipitate lime from limewater. After diſtillation, the remainder contains phoſphorated lime, pure lime and charcoal, and when calcined in the open air, the charcoal is conſumed and the whole reduced to a white powder. The two former may be diſſolved in marine acid, which, when evaporated to dryneſs, will be retained only by the lime; ſo that water will then ſeparate the muriated lime, and the phoſphorated may afterwards be ſubmitted to the uſual analyſis.

Bone earth calculus. Beſides that of Scheele, and the two already noticed, there is, according to Dr. Wollaſton, alſo a fourth ſpecies of calculus occaſionally formed in the bladder, diſtinct in it's appearance, and differing in it's component parts from the reſt, for it conſiſts entirely of phoſphorated lime. It's ſurface is generally of a pale brown, and ſo ſmooth as to appear poliſhed; when ſawed through, it is formed very regularly, laminated, and the laminæ in general adhere ſo ſlightly to each other as to ſeparate with eaſe into concentric cruſts. In a ſpecimen from Dr. Baillie, each lamina is ſituated in a direction perpendicular to the ſurface, as from an aſſemblage of cryſtallized fibres. Bone earth calculus.

This calculus diſſolves entirely, though ſlowly, in marine or nitrous acid, and, conſiſting of the ſame elements

as earth of bones, may undergo a ſimilar analyſis, unneceſſary to particularize.

By the blowpipe it is immediately diſcovered to differ from other urinary calculi; it is at firſt ſlightly changed, but ſoon becomes perfectly white, ſtill retaining it's form till urged with the utmoſt heat from a common blowpipe, when it may at length be completely fuſed. But even this degree of fuſibility is ſuperior to that of bones. The difference conſiſts in an exceſs of calcareous earth contained in bones, which renders them leſs fuſible. This redundant proportion of lime in bones renders them alſo more readily ſoluble in marine acid, and may, by evaporation of ſuch a ſolution, be ſeparated, as in the laſt experiment upon mulberry calculus. The remaining phoſphorated lime may be rediſſolved by a freſh addition of marine acid, and being now freed from redundant lime, will, upon evaporation of the marine acid, aſſume a cryſtalline form. As the laminated calculus contains no exceſs of lime that will at once yield ſuch cryſtals, their appearance is deſcribed in the account of the calculus of the proſtate gland, by this chemiſt, and in the firſt experiment.

Lithrontriptics.

With reſpect to the remedies for this diſeaſe, Dr. Wollaſton is of opinion, that when a calculus is diſcovered by the evacuations to be of the fuſible kind, there appears a more favourable proſpect of relief than with reſpect to the mulberry calculus; for any acid that is carried to the bladder will act upon the triple cryſtals, and moſt acids will alſo diſſolve the phoſphorated lime, whilſt alcalis, on the contrary, would rather have a tendency to add to the diſeaſe. Beſides this ſpecies, the fuſible calculus has afforded deciſive marks of it's preſence in the caſe which furniſhed this chemiſt with his ſpecimen of triple cryſtals, and by the deſcription given by Forbes (in his

Treatiſe upon Gravel and Gout, ed. 1793. p. 65.) of a white cryſtallized precipitate, no doubt is entertained that his patient laboured under that variety of the diſeaſe.

With reſpect to the mulberry calculus, it appears, that an intimate knowledge of it's properties will leave but ſmall proſpect of relief from any ſolvent; but by tracing the ſource of the diſeaſe ſome hopes may be entertained of preventing it. As the ſaccharine acid is known to be a natural product of a ſpecies of oxalis, it ſeems more probable that it is contained in ſome other vegetables, or their fruits taken as aliment, than produced by the digeſtive powers, or ſecreted by any diſeaſed action of the kidneys. The nutriment would therefore become a ſubject of minute inquiry, rather than any ſuppoſed defect of aſſimilation or ſecretion.

As to the bone earth calculus, although ſo nearly allied to that of the *proſtate*, it is ſtill manifeſtly different, and cannot be ſuppoſed to originate from that ſource; but if ever the drinking of water impregnated with calcareous earth gave riſe to ſtone in the bladder, Dr. Wollaſton thinks, that this would moſt probably be the kind generated, and that the remedy muſt evidently be of an acid nature.

Although from want of ſufficient attention to the varieties of ſediment from urine, and want of information with regard to the diverſity of urinary calculi, the depoſits peculiar to each ſecretion are yet unknown; it ſeems probable to this chemiſt, that no long courſe of obſervation would be neceſſary to aſcertain with what ſpecies any individual may be afflicted.

The lithic, which is by far the moſt prevalent, fortunately affords great variety of proofs of it's preſence. Particles of red ſand (as they are called) are it's cryſtals. Fragments alſo of larger maſſes and ſmall ſtones are frequently paſſed, and it is probable that the majority of ap-

pearances in the urine, called purulent, are either the acid itſelf precipitated too quickly to cryſtallize, or a neutral compound of that acid with one of the fixed alcalis.

Dr. Pearſon. The experiments and obſervations which Dr. Pearſon has made on this ſubject, are principally on a ſubſtance which he has found to be very generally a conſtituent part of both urinary and arthritic concretions. This ſubſtance is obtained by diſſolving it out of theſe concretions, by lye of cauſtic fixed alkali, and precipitating it from the ſolution by acids. This was the method by which Scheele ſeparated it; but according to Dr. Pearſon, he did not conſider it's importance, nor of courſe inveſtigate it's properties; he even does not ſeem to have been aware of it's being a diſtinct conſtituent part of the urinary concretion, for when he relates the experiments of precipitating matter from the nitric ſolution of calculus by metallic ſalts, no diſtinction is made between the precipitations in this experiment and that in the former, yet Dr. Pearſon ſhows, that in the one caſe the precipitate is a peculiar animal oxyd, and in the other they are metallic phoſphats.

As Scheele obtained an acid ſublimate, it has been imagined by ſome writers, that the precipitate by any acid (even by the carbonic) from the alkaline menſtruum was an acid, the ſame as that obtained by ſublimation, and which, in the new ſyſtem of chemiſtry, has been denominated *lithic acid*; but the experiments of Dr. Pearſon ſhow that theſe ſubſtances are different ſpecies of matter.

The calculi he made uſe of were of two ſorts: the one was white, ſmooth, and lamellated; the other of a nut-brown colour, with an uneven ſurface; both were roundiſh, and the powder of both mixed together.

Diſcovers a peculiar animal The precipitate obtained by the ſolution of this powder in lye of cauſtic ſoda, and the addition of diluted ſul-

phuric acid to ſaturate the alkali, when waſhed and dried, was a maſs of very light, whitiſh cryſtal, reſembling mica, and after having been ſubmitted to examination by chemical means, afforded the following concluſions as the moſt obvious. oxyd, called uric oxyd.

1. It appears that at leaſt one half of the matter of the urinary concretions united to cauſtic ſoda, &c. is precipitated from it by acids.

2. This precipitate does not indicate acidity to the moſt delicate teſts; and as it is inodorous, taſteleſs, and ſcarcely ſoluble in cold water, does not unite to the alkali of carbonat of potaſh, of ſoda, or of amoniac, nor to oxyd of mercury, nor to the lime of lime water, nor decompound ſoaps, or pruſſiate of iron; and as its combination with cauſtic ſoda reſembles ſoap, more than any other double ſalt known to conſiſt of an acid and alkali, this precipitate does not belong to the genus *acid.*

3. As this precipitate could not be ſublimed, without being decompounded, like animal matter, and alſo for the above reaſon, it cannot be the ſame thing as the *acid ſublimate* of Scheele, or the ſuccinic acid.

4. As it does not appear to be precipitable, nor form a viſcid ſolution with water, it cannot be referred to the *animal mucilages.*

5. On account of it's manner of burning in the air under the blow-pipe, and it's yielding, on expoſure to fire in cloſe veſſels, the diſtinguiſhing products of animal matter, (eſpecially ammonia and pruſſic acid) as well as on account of it's affording a ſoap-like matter with cauſtic ſoda, Dr. Pearſon conſiders this precipitate as a ſpecies of animal matter; and from it's compoſition being analogous to that of the ſubſtances called in the new chemiſtry *animal oxyds,* that it belongs to this genus. It's peculiar and ſpecific diſtinguiſhing properties are

imputrefcibility, facility of cryſtallization, inſolubility in cold water, and that moſt remarkable property of all others, *producing a pink or red matter, on evaporation of it's ſolution in nitric acid.*

Having found this precipitate to be an oxyd, and not, as commonly ſuppoſed, an acid, this chemiſt thought it probable, that, like other analogous oxyds, it was *acidifiable*; but after making the attempt to effect this by means of the oxymuriatic, the nitro-muriatic, and the nitric acid, which are capable of acidifying ſimilar oxyds, his hopes of acidifying this animal oxyd were exploded: he was however indebted to that purſuit for the curious diſcovery of the change of this moſt common baſis of urinary concretions (the animal oxyd) into ammonia and carbonic acid, by the oxygen of the above acids, which will be found extremely important in the explication of ſeveral phenomena. For it now appears, according to this chemiſt, that the inflammation on evaporation of the nitric ſolution of this animal oxyd, aroſe from the nitrat of amonia, the *nitrum flammans* of the old chemiſts, compounded in the experiment. This inflammation alſo ſometimes takes place, on evaporation of nitric ſolutions, both of urinary concretions, and of urine itſelf evaporated to the ſtate of ſoft extract, on account of the ammonia already exiſting in the ſubſtances. The compoſition of ammonia alſo explains the diſappearance of the whole matter of ſome ſorts of urinary concretions, a very ſmall reſidue of black matter excepted, by repeated affuſion and evaporation of nitric acid, from the ſolution of them in this menſtruum.

With reſpect to the matter which remained on the ſtrainer, after the filtration of the ſolution of the powdered calculus in the lye of cauſtic ſoda, it was on being dried an impalpable white, taſteleſs, heavy powder, and on being ſubmitted to experiment, appeared to conſiſt of

phoſphat of lime; accordingly three hundred grains of urinary concretions examined by Dr. Pearſon appear to have contained of

	Grains
Peculiar animal oxyd	175
phoſphat of lime	96
ammonia (and moſt probably phoſphoric acid united to the ammonia) water, and common mucilage of urine, not collected and weighed, by eſtimation	29
	300

The next object of this chemiſt was to obtain the acid ſublimate of Scheele, or lithic acid, as it has been called, and to compare it with the before mentioned animal oxyd.

Having taken 100 grains of an urinary concretion which had been previouſly found to contain principally the above animal oxyd, they were expoſed in a tube for that purpoſe to the fire, firſt to a low temperature, and gradually to a very elevated one; by which means, beſides a gas amounting to 24 oz., which conſiſted of nearly 16 of carbonic acid gas, and air with a larger proportion of nitrogen gas than is found in atmoſpheric air, an offenſive ſmell of empyreumatic animal oil mixed with that of pruſſic acid, 20 grains of a brown ſublimate of carbonat of ammonia and a reſidue of 30 grains of an almoſt pure carbon, with 10 grains of heavy black and brown matter, in which were many ſmall white ſpiculæ, a dark gray matter was obtained which weighed 15 grains. It had been raiſed about half an inch above the carbonaceous reſidue. This ſublimed gray matter on examination was found not to contain any ammonia, nor throw down any pruſſiat of iron with ſulphat of iron. It reddened turnſole paper and tincture. It was ſoluble in cauſtic ſoda, from which ſolution muriatic acid gave no

precipitate, for although on dropping it into the ſolution, a milkineſs appeared, the liquid ſoon grew clear again.

Ten grains of this ſublimate diſſolved in four ounces of boiling water, and on evaporation to half an ounce, a copious depoſit took place, on cooling, of white ſpiculæ, which Dr. Pearſon thinks, are analogous to benzoic acid. The ſublimate had a ſharp, but not ſour taſte. Being boiled in muriatic and nitric acids, no ſolution took place, and what is more particularly to be obſerved is, that it left no red or pink matter on evaporating the nitric acid from it. The ſulphuric acid only diſſolved by the acid of heat, without effervescence, from which nothing was precipitated by cauſtic ſoda; on evaporating the ſolution to dryneſs, black fumes aroſe, leaving behind only a black ſtain. This ſublimed matter did not render limewater turbid. Boiled in muriatic acid, ſo as to carry off all but a very little free acid; on the addition of limewater, there was no turbid appearance, but milkineſs enſued on adding oxalic acid. The whole of this ſublimate, with the ſpiculæ, in the ten grains before mentioned, which appeared to be of the ſame nature, amounted by eſtimation to 18 grains; and Dr. Pearſon looks upon this to be the acid ſublimate of Scheele.

This experiment was repeated a fourth time, and affords evidence, according to this chemiſt, of the wide difference between the animal oxyd and the acid ſublimate of Scheele.

If this concluſion be allowed to be juſt, it will be neceſſary to give a name to this urinary animal oxyd. Agreeably to the principles of the new chemical nomenclature, the name ſhould be lithic oxyd. But the term lithic this chemiſt conceives to be a groſs ſoleciſm, and he prefers the name of *ouric or uric oxyd*; and although it's exiſtence in arthritic as well as in urinary concretions may be an objection, ſtill from it's being found in greater

abundance by far in the urinary paſſages than in other ſituations, and therefore falling under common obſervation as an ingredient in the urine, philology may allow it's admiſſion.

The preceding facts and experiments are applicable to a variety of uſes in chemical inveſtigation; ſince we are now not only able to detect in the eaſieſt manner the *preſence* of the minuteſt proportion of the above animal oxyd in urinary concretions, and alſo in other ſubſtances, but even to determine it's *proportion* to the other conſtituent parts, in the ſpace of a few minutes, in moſt caſes, and in all in a very little time; without any other apparatus than nitric acid, a round bottomed matraſs or glaſs diſh, and a lamp; by which method Dr. Pearſon has examined above 300 ſpecimens of concretions of the human ſubject and other animals, principally urinary, and alſo many other from other parts, particularly thoſe from the joints, and he found,

1. That out of 200 ſpecimens of urinary calculi, not more than ſix did not contain the animal oxyd, *i. e.* about 32 out of 33 contained it.

2. That the proportion of this oxyd was very different, varying from $\frac{1}{200}$ (excluſive of water) to $\frac{199}{200}$; but for the moſt part, varying between $\frac{80}{200}$ and $\frac{140}{200}$, for in ſome the interior part contained this oxyd, and the exterior part not, whilſt in others on the contrary, the exterior did, and the interior did not.

3. That the common animal mucilage of urine is frequently found in concretions, in very different proportions, but is, perhaps, never a principal conſtituent part of them.

4. That the animal oxyd was not preſent in the urinary or any other concretions of any animal but the human kind.

5. That this animal oxyd is prefent alfo in human arthritic calculi, but not in thofe of the teeth, ftomach, inteftines, lungs, brains, &c.

From thefe experiments on the acid fublimate, it appears very doubtful to this chemift, whether the *lithic acid* of Scheele exifts as a conftituent of urinary concretions, or is compounded in confequence of a new arrangement taking place of the elementary matters of the concretion, by the agency of fire; but it is demonftrated, that the urinary animal oxyd is really a conftituent part, and even a principal one, of almoft all human urinary calculi.

Befide the analyfis of the human calculus, we are indebted to the fame ingenious chemift for fome experiments and obfervations on the urinary calculi of the dog, the rabbit, and the horfe.

Calculus of the dog.

1. *Urinary calculus of the dog.* This calculus may be looked upon as a great curiofity, being, perhaps, the only fpecimen in London. The animal was in perfect health, and diffected by H. Leigh Thomas.

It's furface is oval, $3\frac{3}{4}$ inches in length, and three in breadth, white as chalk, and rough and uneven on it's furface. No nucleus was found on being fawed through, it was not laminated, but near the centre radiated, and it contained fhining *fpicula*. In the other parts it was generally compact and uniform in it's texture. It weighed nearly 10 ounces and a half. It's fpecific gravity was greater than that of human urinary concretions in general, which this chemift has learned to be the cafe from experience, with refpect to the urinary and inteftinal concretions of other brute animals, efpecially thofe of the horfe.

The fpecific gravity of the prefent calculus was 1,7.

That of a human urinary calculus called mulberry cal-

culus, which confifted almoft entirely of uric oxyd, was 1,609, and that of another of the fame compofition, but quite fmooth, and extracted by Ford, was 1,571.

1. The prefent calculus of the dog had no tafte, nor fmell, till expofed to the fire.

2. Expofed to the blowpipe it firft became black, and emitted the fmell of common animal matter; it next fmelled ftrongly of empyreumatic *liquor cornu cervi*, and after burning fome time, became inodorous and white, and readily melted, like fuperphofphat of lime.

3. Triturated with lye of cauftic foda, there was a copious difcharge of ammonia.

4. It formed a clear and colourlefs folution, on boiling in nitrous acid, and evaporated to drynefs left a refidue of *white bitter matter*, which emitted a weak fmell of animal matter under the blowpipe.

5. A mixture of 150 grains of the powdered calculus, and 2 pints and a half of pure water, being diftilled to three ounces, the liquor contained only a little ammonia. The three ounces of refiduary liquor being filtered and evaporated, gave 20 grains of phofphat of ammonia, with a little animal matter, and the refiduary undiffolved matter amounted to 67 grains.

6. Thefe 67 grains being triturated with four ounces of cauftic foda lye, difcharged very little ammonia. They likewife afforded phofphat of lime and animal matter.

7. This refiduary infoluble fubftance in cauftic lye, under the blowpipe, firft turned black, and then grew white, but could not be melted.

Thefe experiments demonftrate, that the above concretion contained none of the uric oxyd, but was compofed, principally at leaft, of phofphats of lime and ammonia, and animal matter.

The prefent inftance leads this chemift to explain the

reafon of the fufibility of calculi. The above experiments prove it to depend on the difcharge and decompofition of the ammonia of the phofphat of ammonia, during the burning away of the animal matter; hence the refiduary phofphoric acid readily fufes, and uniting to the phofphat of lime, compofes fuperphofphat of lime, a very fufible fubftance. The phofphat of ammonia being diffolved by water, or cauftic alcaline lye, the remaining matter is infufible, being phofphat of lime.

A very hard, brittle, and blackifh inteftinal calculus of a dog, was found to be of greater fpecific gravity than human urinary calculi, and to have the fame compofition as that of the dog above defcribed.

This alfo was found to be the compofition of a white, fmooth, round, inteftinal calculus of a horfe, the fpecific gravity of which was 1,791.

Calculus of a rabbit.

2. *Urinary calculus of a rabbit.* Dr. Pearfon likewife looks upon this as a curiofity, being the only inftance he has feen. The animal from which it was taken was very fat and healthy.

It's form was fpherical, and of the fize of a fmall nutmeg. It's colour a dark brown, it's furface fmooth, and it's confiftence hard, brittle and heavy. When broken, it appeared to confift of concentric laminæ. It's fpecific gravity was 2. It confifted principally of carbonat of lime and common animal matter, with, perhaps, a very fmall proportion of phofphoric acid, but contained no uric oxyd.

Calculus of the horfe.

3. *Urinary calculus of the horfe.* This chemift has examined feveral fpecimens in cabinets, faid to be vefical calculi of this quadruped, and he found none of them to contain the uric oxyd, but that they confifted (as well as the calculi from the ftomach and inteftines of the fame animal) of phofphat of lime, phofphat of ammonia, and

common animal matter, which melted like ſuperphoſphat of lime, after burning away the animal matter and ammonia.

This concretion, given by Dr. Baillie, was of a blackiſh colour, very hard and brittle in it's conſiſtence, and without ſmell or taſte. It felt heavier than human urinary calculi. From the experiments of this chemiſt, it appears, that like the former calculus from a rabbit, it conſiſted of carbonat of lime, and common animal matter.

A renal calculus of a horſe, in Heaviſide's collection, appeared, on examination, to conſiſt of carbonat of lime and common animal matter. Another ſpecimen of the ſame ſort conſiſted of phoſphats of lime and ammonia, and common animal matter. It fuſed under the blowpipe. A veſical calculus was compoſed of the ſame ingredients.

Dr. Pearſon has met with two inſtances of a depoſit of a prodigious quantity of matter in the urinary bladder of horſes, which had not cryſtallized, or even concreted; it amounted in one ſpecimen given to him by Dr. Marſhall, to ſeveral pounds weight, and in the other, which is in the poſſeſſion of Home, to about 45 pounds. It's compoſition was principally carbonat of lime and common animal matter.

Such depoſits, it appears, are not unfrequent.

This chemiſt has not found any inſtance of human urinary calculi of ſimilar compoſition to that of the rabbit, and thoſe of horſes, above deſcribed, which conſiſt of carbonat of lime and animal matter; and he is of opinion, that they very rarely occur of a ſimilar compoſition to thoſe of the dog and horſes, which were found to conſiſt of phoſphat of ammonia, phoſphat of lime and animal matter, without containing *uric oxyd.*

The difference in the conſtitution of urinary concretions may depend on the difference of the urinary organs of different animals, on the food and drink, and on the various diſeaſed and healthy ſtates of the urinary organs.

Dr. Pearſon has not found the uric oxyd in the urinary concretions of any phytivorous animal; but whether it be formed in the human animal, when nouriſhed merely by animal matter, muſt be determined by future obſervations. He found the ſtomach concretion, called *oriental bezoar*, to conſiſt merely of vegetable matter, as did the inteſtinal concretion of a ſheep.

Brugnatelli. Brugnatelli, upon ſubmitting different kinds of calculi to chemical experiment, found,

1ſt. That all, as ſeveral chemiſts had obſerved, were in part ſoluble in water, when caſt into it in a pulverized ſtate at the boiling point. The filtered ſolution, whilſt warm, was of a yellow colour. The portion that remained on the filter was not entirely ſoluble in freſh water.

2d. That the part ſoluble in water was the acidulous phoſphat of lime, which he found to exiſt in the greateſt number of *white calculi.*

Brugnatelli ſeems ſurpriſed that Scheele and Bergman, and other chemiſts who have examined this ſubſtance, ſhould have looked upon the ſoluble part to be the lithic acid, and that Scheele ſhould maintain that theſe calculi contained no lime.

Fourcroy, however, ſupports the fact, that this matter, ſoluble in water, is the lithic acid, and he never met with the acidulous phoſphat of lime in the concretions, except in one; it is the lithic acid which always, in the ſolution, reddens litmus.

3d. That the portion of the veſical calculus, which was not diſſolved by the water, contains a ſubſtance abounding

in the oxalic radical. As a proof of this, he poured fome concentrated nitric acid on the infoluble refiduum; which it diffolved with a little effervefcence, and a difengagement of very thick, red, nitrous vapours. There was no refiduum. The folution was of a yellow colour, and ftained the fkin of a rofe colour, which difappeared on touching it with the nitric acid. On pouring into this folution fome oxalic acid, there was no veftige of the prefence of lime. There was no turbidnefs. Brugnatelli, however, did not conclude from this, that there was none of this earth, having found lime to exift in faline combinations, without being indicated by the oxalic acid. He had befides obferved, that calculi and fediments of urine, when treated with the nitric acid, afforded oxalic acid, from which he contended, that the lime was in a ftate of oxalat, already faturated, and taken again into folution by the nitric acid. In fuch a cafe the oxalic acid was no longer capable of acting on the lime.

4th. That a great part of the calculus, foluble in the nitric acid, is converted into oxalic acid. As a proof of this, a certain quantity of the folution of the refiduum of the calculus in nitric acid was evaporated until the entire difappearance of the nitric acid, and afterwards tried with lime water, a depofit formed as if it had been with the folution of pure oxalic acid.

He alfo diffolved the refiduum of three different calculi in concentrated nitric acid, and gradually diftilled the three folutions; after a fufficient concentration, they were placed in a cool place. The next day he found in one of them fome beautiful cryftals of oxalic acid, with a portion of thick liquor, from which he could not extract any more cryftals. The other two gave no appearance of cryftallization, although the liquors contained a great deal of the oxalic acid in a combined ftate.

He decompofed, by the means of ammonia, another

another portion of the calculous folution by the nitric acid, and obtained a cryftallized precipitate fomewhat tranfparent. This when dried was of a fhining white colour, compofed of fmall lamellated cryftals. It's favour was rather fharp, and it reddened the tincture of litmus. This cryftalline mafs eafily diffolved in the nitric acid, of which it deepened the colour; in diftilled water, it formed a turbid folution that became clear on repofe, and depofited a little white matter refembling lime. This folution had fcarcely any diftinct favour. The oxalic acid did not render it turbid, but produced a very abundant precipitate in the lime water, which was the oxalat of lime.

The cryftals feparated by the ammonia from the nitrous folution of the calculus, appear according to Dr. Brugnatelli to be the acidulous oxalat of lime. Diftilled water feparated the free acid. He neither met with the oxalic nor the pruffic acid in the calculi he has analyzed. The faline precipitate, feparated from the calculous folution in the nitric acid by ammonia, appears to deferve to be better examined.

Fourcroy and Vauquelin.

Fourcroy and Vauquelin, inftead of finding urinary calculi conftantly or totally formed of uric acid (lithic acid) as Scheele had announced, or phofphat of lime mixed with this acid, according to Hartenkeil and Pearfon, have difcovered from their numerous experiments, befides the uric acid and phofphat of lime, five other conftituent parts which were unknown before to exift in human urinary calculi, viz. ammonia, ammoniaco-magnefian phofphat, oxalat of lime, filex, and an animal matter.

Difcover 5 new fubftances in calculi.

The afpect of the calculus alone is almoft always fufficient to indicate the nature of it's mafs, when it is formed of only one fubftance, or of the different ftrata of which it is compofed. If the appearance alone be

not ſufficient to give an exact notion of it's nature, or that of it's ſtrata, it is readily known by means of a few ſmall chemical trials to be related. The chemical characters of each of theſe ſubſtances are ſo well laid down by theſe two chemiſts, as to make it impoſſible almoſt to be miſtaken in them, at the ſame time it gives riſe to a new claſſification of calculi, according to their component parts.

Uric acid, for an account of which vide lithic acid, art. acids. Uric acid.

Urat of ammonia. This is more rare in calculi than the uric acid; it is found in thin ſtrata of a texture but little cryſtallized, eaſily rubbed down, of a colour reſembling coffee with milk, very rarely alone, often mixed with uric acid, or with phoſphats interpoſed between their ſtrata, eaſily known by it's rapid ſolubility in the lye of cauſtic potaſh, during which there is an extrication of ammonia, whilſt pure uric acid affords none. Urat of ammonia.

Phoſphat of lime. This is found of a white colour, rough, granular, friable, or in very brittle white ſtrata, marking the hands, paper or ſtuffs, like chalk, breaking on being ſawed, inſipid to the taſte, inſoluble in water; ſoluble in nitric, muriatic, and even in the acetous acid, forming acid ſolutions, precipitated by ammonia and the alkalis, eſpecially by the oxalic acid. It forms white, friable, earthlike calculi, or the calculous ſtrata of that nature. It is never alone in calculi; it is intimately mixed with a gelatinous animal matter, which remains in the form of a membrane, when ſuſpended in weak acids ſo as to diſſolve the ſaline part; it is this animal matter that produces the coal obtained in the calcination of theſe ſpecies of white friable calculi, and the fatuous odour of glue when they are boiled in water. Theſe ſpecies of calculi are eaſily diſſolved in the bladder by muriatic acid, ſo much diluted as ſcarcely to be ſapid. Phoſphat of lime.

Phosphat of ammonia-co-magne-

Phoſphat of ammoniaco-magneſia. This is white, and ſemitranſparent, lamellated, with ſpathic ſtrata ſometimes cryſtallized in priſms or in the form of cock's combs on the calculi, of a faint ſweetiſh ſavour, reſembling gypſeous alabaſter, more ſoluble in water than the preceding ſubſtance, very ſoluble in the weakeſt acids, decompoſed by fixed alcali, which diſengages the ammonia and precipitates the magneſia. It never forms urinary calculi of itſelf; it is often mixed with phoſphat of lime, always in the white friable calculi; ſometimes it covers of itſelf a nucleus of uric acid, or oxalat of lime. The ſame animal gelatinous matter is found in it as in the preceding. It is of all calculous matter the moſt ſoluble, by an injection of extremely weak and diluted muriatic acid into the bladder.

Oxalat of lime.

Oxalat of lime. Theſe chemiſts found it forming the ſolid baſis of the *mulberry* calculi, ſo called from the inequality of their ſurface, and their blackiſh brown colour. This ſalt is combined in them with an animal matter the moſt abundant of all that exiſt in calculi; this combination is very denſe, difficult to ſaw, taking the form of caps placed upon each other, which give riſe to projecting tubercula, as it were depoſited on a common centre; receiving a poliſh like that of ivory; diffuſing a fatuous and ſpermatic odour on being cut with the ſaw; internally of a gray colour; inſoluble and not to be decompoſed in alkalis; ſoluble in nitric acid, even when weak, but ſlowly, and with difficulty; only to be decompoſed by the carbonats of potaſh, and of ſoda, by which it may be analyzed, leaving, after being decompoſed and burnt in the fire, a quicklime which is eaſily known. Theſe *mulberry* calculi, which are pretty often alone, and likewiſe often covered with uric acid or earthy phoſphats, are thoſe kinds which ought the moſt to reſiſt menſtrua injected into the bladder.

Silex. Thefe chemifts have only met with this earth twice on analyzing 300 calculi with great exactnefs; hence it rarely enters their compofition. It is found mixed with the uric acid, and with earthy phofphats in calculi, the compofition of which is very complicated. From it's being fo feldom met with, it can fcarcely be counted amongft the number of calculous materials. Silex.

Animal matter. This, which accompanies one or the other of the fix preceding materials, and which feems to form their gluten, bond or cement, appears to vary according to the nature of thefe materials, and may be the determining caufe of the precipitation of fome or of others; for all, except the oxalat of lime which appears to be a real morbific matter, are the natural elements of human urine. This animal matter is fometimes in the form of a gelatin, or a fort of albumen; at other times analogous to thefe, and merits a further inveftigation. Animal matter.

The old method of claffing urinary calculi was, according to their form, colour, fize, furface, &c.; but a more minute inveftigation of their component parts, and the experiments in particular of Fourcroy and Vauquelin, have induced the firft of thefe chemifts to form them into 12 fpecies. On looking over the feven different matters which conftitute human urinary calculi, and feeing the conftancy by which each is accompanied by an animal fubftance, it appears there is not one of them that is formed entirely of one fpecies of matter; and the animal fubftance exifts in all, and forms almoft always it's gluten; befides, as it has not fuch influence as to give them any fenfible variety in their properties, Fourcroy has not included it in his claffification. After having analyzed more than 600 human urinary calculi, and marked the facts this analyfis afforded, he has diftinguifhed them into three genera. 1ft. Thofe formed only of one fubftance, befides the animal matter which Fourcroy makes a new claffification.

unites their particles. 2d. Thofe compofed of two calculous fubftances. 3d. Thofe containing more than two different fubftances, and often even four. Thefe three genera are divided into 12 fpecies. Of thefe three alone belong to the firft genus.

1. The firft fpecies are thofe compofed of uric acid.

2. The fecond of urat of ammonia.

3. The third of oxalat of lime. Neither the phofphat of lime, nor the phofphat of ammoniaco-magnefia, nor filex, has been yet found alone.

There are feven fpecies in the fecond genus, *i. e.* among thofe calculi formed of two calculous fubftances befides the animal matter, which matter renders them ternary mixtures, as it rendered the firft binary. Thefe feven fpecies are as follows:

4. The firft contains uric acid and earthy phofphats in very diftinct ftrata.

5. The fecond, uric acid and earthy phofphats intimately mixed together.

6. The third, urat of ammonia and phofphats in diftinct ftrata.

7. The fourth. The two preceding materials intimately mixed.

8. The fifth. Earthy phofphats mixed together either intimately or in their ftrata.

9. The fixth. Oxalat of lime and uric acid in diftinct ftrata.

10. The feventh. Oxalat of lime and earthy phofphats in diftinct ftrata.

Laftly. The two laft fpecies form the third genus, or thofe calculi containing three or four calculous fubftances, viz.

11. The firft contains uric acid or urat of ammonia, earthy-phofphats and oxalat of lime.

12. The fecond. Uric acid, ammoniacal urat, earthy phofphats and filex.

Such is the claffification which this chemift has formed of the various human urinary calculi, for a more detailed account of which, the reader is directed to his *Syftème des Connaiffances Chimiques, &c.* which has lately been publifhed.

Calculus of a pig. This was found in the bladder of a pig, after having been killed by the butcher. It's weight was rather more than three decigrams, it's fpecific gravity to that of diftilled water, as 19,300 to 10,000. It's form was an oblong oval; it's furface fmooth, without any depreffion, and of a white colour; it was pretty tender, and gave way to the knife. When divided in the middle, the external ftratum was very thin and furrounded it on all parts, but was much thicker towards the extremities of it's great diameter, than towards that of it's fmall one, without fhowing any determinate cryftallization; under this firft ftratum was a light yellowifh zone, beneath which fome beautiful cryftals of a perfect whitenefs were feen, in the form of needles, converging from the circumference to the centre. On analyfis, this calculus appeared to confift of phofphat of lime, but from the fmallnefs of the quantity, Bertholdi was incapable of determining exactly the proportion of it's conftituent parts.

Bertholdi.

Calculus of the pig.

Calculus renalis. The kidneys, like the bladder, are very fubject to be the feat of calculi, and as they are perhaps the moft expofed of any part of the body to that morbid affection under which concretions are found, they ought to be confidered as the fource from which the vefical calculus takes it's origin. Indeed, if the kidneys be confidered as the natural filters of the urine, it may feem fomewhat extraordinary, that fuch concretions do not take place much oftener than they do. The human frame is very fubject to this difeafe. When thefe renal calculi are fmall, they are forced from the kidneys by the

urine, descend by the ureters, and are evacuated under the form and name of gravel. When of a larger size, they press against and wound the canals through which they pass, giving rise to nephritic pains, voiding of blood, &c. Often after having been forced into the bladder, and their size preventing them from passing through the urethra, they become the nucleus of the vesical calculus, which can only be extricated by the operation of lithotomy.

Sometimes they remain in the kidneys, increase in size, by degrees, from a successive addition of several strata, and become so large as to occupy all the canals through which the urine is conveyed from this glandular viscus. In these cases the renal calculus assumes the ramified form of the internal structure of the kidney, the consequences of which are very long diseases, without remedy, very acute and repeated pains, ischuries, dysuries, and evacuations of blood and pus, by the urethra. By degrees, the substance of the kidney is corroded and destroyed by the pressure and continual irritation of these substances, and at last nothing remains but a membrane or sort of bag full of pus, and enclosing the calculus. This dreadful disease, which is not very rare, sometimes continues many years; it even sometimes is present without any of those symptoms which characterize it's existence: thus the works of anatomists, and particularly of Morgagni, give the histories of several bodies, which, on dissection, have shown the destruction of one of the kidneys, and the presence of a calculus, without the previous symptoms, though very severe, having led to a knowledge of the cause.

The renal calculus of the human species is of the same nature as the stone of the bladder, according to Fourcroy, who having examined several, found them composed of the concrete lithic acid. They are always perforated,

Fourcroy.

Human renal calculus.

and full of cavities, in which, as well as on their ſurface, regular ſhining cryſtals of the phoſphats of ſoda and of ammonia are often found; and to examine them, it is only neceſſary to ſteep them a few hours in water, during which the cryſtals diſappear, and their nature is diſcovered by examining the ſolution.

Animals as well as men are ſubject to renal calculi. Morand, junior, has even diſcovered that rats have very frequently numerous concretions in their kidneys, although he appears not to have examined them. A comparative analyſis, however, between the human and animal renal calculus, might throw great light on the ſubject, ſince the nature of the calculi has great relation to the urine, which differs in various claſſes. The ſingular properties of the urine of the horſe are well known. This, which is much more charged with matter than the human, becomes turbid the inſtant it is evacuated. The powdering matter which falls down is found to be for the moſt part chalk, whilſt the precipitation from human urine, particularly towards the termination of certain diſeaſes, is the lithic acid; and it appears from the experiments of Fourcroy, that the nature of the renal calculus of the horſe anſwers to that of the urine of that animal.

Renal calculus of the horſe.

The form of this calculus was exactly that of the kidney, the place of which it occupied, and it's extremities were terminated by vegetations reſembling the cauliflower. It was of a brown colour on it's ſurface, and appeared covered with an infinity of ſmall ſhining plates reſembling fragments of ſand, that reflected the rays of light. On it's edges were ſeveral unequal cavities. Almoſt all it's ſurface was mammellated, and in ſome places were portions of membranes. Great difficulty aroſe on cutting it, from it's hardneſs, but when the inſtrument had got three or four lines, it paſſed eaſily; this aroſe from the

denſity of the exterior, whilſt the middle was formed of very porous and tender ſtrata. It weighed 15 ounces five drachms 36 grains. It appears, from it's analyſis, that one quintal of it was compoſed of 68 parts of the carbonat of lime, and 22 of the phoſphat of lime, both of them earthy inſoluble ſalts. This difference between the nature of the calculus of the horſe and that of man, is not extraordinary, after the proof of the exiſtence of the carbonat of lime in the urine of that animal.

It's formation, according to Fourcroy, is perhaps, more frequent in ſuch animals than is generally believed, as appears from the facility with which theſe matters are depoſited from their urines. Another iſolated fact was made by this chemiſt, from the examination of the renal calculus of a cat. It had been caſtrated when young; it's renal capſules were found perfectly indurated, and as it were petrified; they appeared to the touch like pieces of ſtone, and the ſame grating ſharp noiſe was heard on cutting them with a knife. They were of a whitiſh colour, and globular grains were eaſily diſtinguiſhed, uniting by a very thin cellular texture. Between the largeſt and moſt diſtant grains, the cavities were filled with a thickiſh ruddy humour. Theſe glands being detached and boiled in a ſolution of potaſh, to ſeparate the cellular texture, after which nothing remained but a number of ſmall hard grains of different ſizes, and detached from each other, were found (after a few had been expoſed to live coals to ſhow they contained no more combuſtible animal matter, by their not blackening) to contain two inſipid and inſoluble calcareous ſalts, viz. the carbonat, and phoſphat of lime; the firſt made about $\frac{3}{4}$ of the whole maſs; the ſecond nearly the remaining quarter. This confirms the opinion, that theſe capſules are only neceſſary in the former part of the life of animals, and in adults are no longer of uſe.

Of a cat.

Calculus arthriticus. The cretaceous looking ſubſtance which ſometimes appears in the articulations of gouty patients, and which Severinus had ſeen of the ſize of an egg, was originally conſidered to be nothing more than chalk, from it's great external reſemblance to that earth; but late experiments have ſhown how little the nature of ſubſtances are to be truly judged of by their exterior appearance, unleſs when accompanied by chemical analyſis. Conſidered as chalk.

It was ſuppoſed by Sydenham, Cheyne, Murray, and ſeveral other celebrated phyſicians, that it was analogous to the matter of the calculus of the bladder; but no analyſis confirmed their ſuſpicions; and according to Van Swieten, it never acquires the hardneſs of the calculus, even after a preſervation of twenty years; and Schenkius affirms that this pulverized tufa formed a ſolid body with water, like gypſum.

The experiments made upon it by Pinelli are worthy of attention. He treated three ounces of this arthritic tufa in a retort, and obtained ſome volatile alkali with a few drops of oil, the reſiduum weighed two drachms; this ſubſtance was tried in ſpirits of hartſhorn, in urine, and in ſal ammoniac, but was found to remain inſoluble in them; on the contrary, it was perfectly diſſolved in the vitriolic and muriatic acids, and even in diſtilled vinegar. With reſpect to it's inſolubility in acids, Dr. Cullen has ſince aſſerted, that it is 'very entirely' ſo; but Wollaſton found, that only the nitrous acid had that power. Pinelli.

Caietan Tacconi, in order to determine by more exact experiments the queſtion which was much diſcuſſed in his time, whether the principle of the gout was acid or alkaline, chemically examined the ſynovial liquor of gouty patients; and having obſerved, that it was equally coagulated by acids and alkalis, concluded, that this diſeaſe might originate from both cauſes, which, ac- Tacconi.

cording to him, ought to conciliate the obfervations of authors, and direct them in the cure of it. However inconclufive might be his labours on this fubftance, there is one remarkable fact he mentions, viz. that from fome, it reddened the fyrup of violets, whilft that taken from others changed it to a green colour.

Roering. It has alfo been confidered to be the earth of bones; and in the Memoirs of the Academy of Stockholm, for 1783, there is an obfervation of Roering, ftating, that fome concretions expectorated by an old man fubject to arthritic paroxyfms, were found to be of an offeous nature, or compofed of phofphoric calcareous falt.

Watfon. Watfon, in the *Medical Communications of London*, vol. i. 1784, examined this fubftance, in order to fee whether it was fimilar to the vefical calculus, as had been reprefented; but having made fome experiments on fome that was taken from a gouty patient during diffection, he concludes that it is very different from the matter of the urinary calculus, becaufe it is foluble in fynovia, and mixes readily with oil and water, which is not the cafe with the urinary calculus. Morveau is of opinion, likewife, that it is very different, but he grounds his opinion only upon certain experiments made by Schenkius, Pinelli, and Whytt, which are far from poffeffing the accuracy required to clear up the matter.

Morveau and Fourcroy.

The obfervations of Boerhaave, Hoffman, Springsfield, Alfton, and Leger, on the good effects of alkaline water, foap, and lime waters, in the cure of arthritic and calculus affections, appear to Fourcroy more proper to afcertain the exiftence of an analogy between thefe two kinds of concretions, than the former are capable of difproving it. But as Morveau obferves, experience alone is fufficient to decide the queftion, and this has lately been accomplifhed by Dr. Wollafton.

At the time this chemift made his experiments, the

prevailing opinion was, that the gouty matter consists of lithic acid, or matter of the calculus described by Scheele. But this idea was not founded on any direct experiments, nor, perhaps, more ably supported than by Forbes, who defended it solely by pathological arguments from the history of the disease. Had he undertaken an examination of the substance itself, he would have found, that instead of a mere concrete acid, the gouty matter is a neutral compound, consisting of lithic acid and mineral alkali, which is proved by the following experiments:

Supposed to be the lithic acid.

Discovered by Dr. Wollaston to be lithiat of soda.

1. If a small quantity of diluted vitriolic acid be poured upon the chalk-stone, part of the alkali is extracted, and crystals of Glauber's salt may be obtained from the solution. Common salt may be more easily procured by marine acid. The addition of more acid will extract the whole of the alkali, leaving a large proportion of the chalk-stone undissolved; which exhibits the following characteristic properties of lithic matter.

a. By distillation, it yields a little volatile alkali, prussic acid, and an acid sublimate, having the same crystalline form as the sublimate observed by Scheele.

b. Dissolved in a small quantity of diluted nitrous acid, it tinges the skin of a rose colour, and when evaporated, leaves a rose-coloured deliquescent residuum.

c. It dissolves readily in caustic vegetable alkali, and may be precipitated from it by any acid, and also by mild volatile alkali; first as a jelly, and then breaking down into a white powder.

2. In distillation of the chalk-stone, the lithic acid is decomposed, and yields the usual products of animal substances, viz. a fetid alkaline liquor, volatile alkali, and a heavy fetid oil, leaving a spungy coal, which, when burned in the open air, fuses into a white salt, that does not deliquesce, but dissolves entirely in water, is alkaline, and

when faturated with nitrous acid, gives rhomboidal cryftals.

Thefe characteriftic properties prove it to be mineral alkali.

3. Cauftic vegetable alkali poured upon the chalk-ftone, and warmed, diffolves the whole without emitting any fmell of volatile alkali. From which it appears, that the volatile alkali obtained by diftillation is a product arifing from a new arrangement of elements, not fo combined in the fubftance itfelf.

4. Water aided by a boiling heat diffolves a very fmall proportion of the gouty concretion, and retains it when cold. The lithic acid thus diffolved in combination with the alkali, is rather more than would be diffolved alone; fo that by addition of marine acid it may be feparated. While the folution continues warm no precipitate is formed; but as it cools, the lithic acid cryftallizes on the fides of the veffel, in the fame manner as the cryftals called red fand do, when an acid is added to recent urine.

The gouty concrete may be eafily formed by uniting the ingredients of which this chemift has found it to confift.

5. If a fragment of lithic acid be triturated with fome mineral alkali and a little warm water, they unite, and after the fuperfluous alkali has been wafhed out, the remainder has every chemical property of gouty matter.

The acid will not fublime from it, but is decompofed (2.) by heat. The alkali may be extracted by the vitriolic or marine (1.), or indeed by moft acids. The compound requires a large quantity of water for it's folution (4.); and while warm the folution yields no precipitate by the addition of an acid; but upon it's cooling the lithic cryftals form as in the preceding experiment.

In each cafe the cryftals are too fmall for accurate ex-

amination, but this chemiſt has obſerved, that by mixing a few drops of cauſtic vegetable alkali with the ſolution previous to the decompoſition, they may be rendered ſomewhat larger. At the firſt precipitation, the cryſtals from gouty matter were not ſimilar to thoſe of lithic acid, but by rediſſolving the precipitate in water with the addition of a little cauſtic vegetable alkali, and decompoſing the ſolution as before, while hot, the cryſtals obtained were perfectly ſimilar to thoſe of lithic acid procured by the ſame means.

Such are the eſſential ingredients of the gouty concretion; and although perhaps in large maſſes, ſome portion of common animal fibre or fluid may be found intermixed, the heterogeneous matter is in too ſmall proportion to invalidate the general reſult that 'gouty matter is lithiated ſoda.'

The knowledge of this compound may lead to a further trial of the alkalis, which have been obſerved by Dr. Cullen to be apparently efficacious in preventing the returns of this diſeaſe (Firſt Lines, DLVIII.): and may induce us, when correcting the acidity to which gouty perſons are frequently ſubject, to employ the fixed alkalis, which are either of them capable of diſſolving gouty matter, in preference to the earths (termed abſorbent) which can have no ſuch beneficial effect.

Calculus pinealis. It is well known, that nothing is more common than to find ſeveral ſmall ſtones or concretions in the pineal gland of the brain; both in the human and that of quadrupeds; but either on account of their ſmallneſs and the difficulty of procuring a certain quantity, or the little account of the utility of the inveſtigation, nothing has been attempted until Dr. Wollaſton, from the delicacy of the teſt of neutral phoſphorated lime, which it's cryſtallization from marine acid afforded, was enabled to detect it in it's ſmalleſt quantity, Dr. Wollaſton.

and by this he found that it formed the bafis of the particles of fand to be felt in this gland; for after they were calcined they cryftallized perfectly from marine acid. But he is of opinion that this fand, which from it's frequency fcarcely merits the name of difeafe, or when amounting to a difeafe, is moft certainly not known by it's fymptoms, would at the fame time, if known, be wholly out of the reach of any remedy.

Calculus proftatus. The calculus of the proftate gland, which may be confidered, as well as the vefical, to be a concretion of the urinary paffages, has alfo been examined by Dr. Wollafton, who thought it merited an inveftigation, not from the frequency of it's occurrence, but from having been fuppofed to give rife to ftone in the bladder.

It appears in the form of fmall ftones occafionally in this gland, and thofe which this chemift had an opportunity of examining were from the fize of the fmalleft pin's head to that of pearl barley, in colour and tranfparency like amber, and appeared originally to have been fpherical; but from contiguity with others, fome had flattened furfaces, fo as at firft fight to appear cryftallized.

Thefe were found to be phofphorated lime in the ftate of neutralization, tinged with the fecretion of the proftate gland.

1. A fmall fragment being put into a drop of marine acid, on a piece of glafs over a candle, was foon diffolved; and upon evaporation of the acid, cryftallized in needles, making angles of about 60° and 120° with each other.

Water dropped on the cryftals would diffolve no part of them; but in marine acid they would rediffolve and might be recryftallized.

2. Vitriolic acid forms felenite with the calcareous earth.

3. By aid of nitrated quickfilver, phofphoric acid is readily obtained.

4. When heated, this calculus decrepitates ftrongly; it next emits the ufual fmell of burnt animal fubftances, and is charred, but will not become white though partially fufed. It ftill is foluble in marine acid, and will in that ftate cryftallize more perfectly than before. Hence he concludes, that thefe ftones are tinged with the liquor of the proftate gland, which in their original ftate (1.) fomewhat impedes the cryftallization. This cryftallization from marine acid furnifhed the before mentioned teft.

This chemift is of opinion, that the calculi of the proftate gland are too rare perhaps to have been ever yet fufpected in the living body, and are but indirectly worthy of notice. For if by chance one of them fhould be voided with the urine, a knowledge of it's fource would guard us againft an error we might otherwife fall into, of propofing the ufual folvents for urinary calculi.

Dr. Wollafton has alfo met with neutral phofphorated lime in a very pure ftate and foft, contained in a cyft under the pleura of coftalis.

Calculus ftomaticus, or bezoard. In the human ftomach, although ftony calculi in ftrata have been found, yet it is very rarely; whilft on the contrary, in that of quadrupeds it is not uncommon to find hairy balls agglutinated by a lymphatic juice; and there is a fpecies of calculus found in the ftomach of fome, called the bezoard, which is in high eftimation. Calculus ftomaticus, or bezoard.

The origin of the name bezoard is uncertain, whether it is derived from pazan or pazar, the name of a buck in the Perfian language, or beluzaar, which fignifies an antidote in the Hebrew, or Chaldean language. Dau- It's etymology.

benton is of opinion, that the name was only given to certain concretions found in the bodies of ſome Aſiatic animals, perhaps the gazelle, antelope, or goat of India, as from the account of travellers they very much reſemble them; it is however very certain, that the animals are of that claſs, viz. with cloven feet, and provided with horns.

After the diſcovery of America, the name of bezoard was alſo given to the concretions found in the animals of that part of the world, ſuch as the pard, chamois, or the goat of Peru. Bezoards are alſo taken from the porcupine, wild boar, tortoiſe, horſe, mule, dog, caſtor, ox, rhinoceros, elephant, man, &c. and are of all ſizes.

Diſtinguiſhed into two kinds. Bezoards are diſtinguiſhed by the names of oriental and occidental, from the parts in which they are procured; the firſt is the moſt ſcarce and of much greater value than the other. The ordinary bezoard is taken from the common domeſtic goat.

1. Oriental bezoard. The oriental bezoards which are taken from a ſpecies of deer in Egypt, Perſia, China, and ſeveral other parts of the Eaſt Indies, are internally and externally of a brown olive colour, generally of a deep hue, and even blackiſh, the ſurface ſhining and poliſhed.

2. Occidental. The occidental bezoards are internally of a whitiſh colour, but their external ſurface is not ſo ſhining, nor ſo poliſhed as the oriental. The ſurface is whitiſh, mixed with yellow or black, moſt often with ſhining tinges, which appear to be gilt or bronzed.

Compoſition of bezoard. Bezoards, according to Bomare, are compoſed of concentric ſtrata, which are not all of them the ſame colour or thickneſs; the ſavour is urinous, they are glutinous, and tinge ſlightly the ſaliva. At the centre of the bezoard, ſome foreign body is almoſt always found, ſuch as ſtraw, hair, grains of corn, wood, nuts, &c.; and

these bodies have served as a nucleus or point for the formation of the strata. Sometimes they rattle on shaking them, which is produced by the hard body in the centre having been detached.

Great sudorific virtues have been attributed to the bezoards, especially to the oriental, and they were believed to be an antidote against poisons. Their price rose according to their size, and from their high value, factitious ones have been substituted, and those compositions which go by the name of pierres de Goa, or de Malacca, are false bezoards. Superstitious ideas of them.

According to Bomare, they are made in the following manner: Lobster's claws, and oyster shells levigated on porphyry are made into a paste with musk and ambergris, then formed into balls of the form of bezoards, which are afterwards rolled upon gold leaf. Those who are desirous of a more exact imitation do not gild them. This however would be necessary to imitate those of the ox, if it be true that they are of a gold colour, and of a metallic brilliancy, when the first strata have been taken away. These factitious bezoards are distinguished by drawing a line with them over a piece of paper that has been rubbed with ceruse, chalk, or lime; if the trace becomes of a greenish or olive yellow, it is a sign of it's being natural; those that are real, imbibe water and alcohol, render them turbid, and effervesce with acids. Method of falsifying the oriental.

Of all the bezoards, the *piedra del porco* is the dearest. It is fat and soapy to the eye and touch, of a greenish or yellowish colour; also reddish or blackish ones are found, and it is almost incredible how highly they are valued in Holland. Bomare saw one about the size of a pigeon's egg, belonging to a Jew, at Amsterdam, who asked 6000 livres for it. They are let out both in Holland and Portugal at a ducat a day to those Value of the real ones.

who fancy themfelves attacked by contagion, and who think they are preferved from it by carrying them as amulets in the fame manner as eagle ftones are ufed in Germany, to facilitate difficult labours, the load-ftone in France to cure a fever, or the jade in Spain, to prevent the gravel. Such is the ftriking portrait in thefe countries of the fuperftition and folly of the human mind.

Bomare looks upon the bezoard to be a ftone found in various parts of certain animals, as the ftomach, falivary canal, inteftines, gall-bladder, and the kidneys, from which it appears that the knowledge of this natural hiftorian was very limited with refpect to this calculus, and that it only was extended to it's medicinal ufe.

The obfervations of Daubenton are much more fatiffactory, more particularly thofe which he has given of the natural hiftorical part. Having, in comparing the *foffile* with the *oriental and occidental bezoards*, defcribed the formation and nature of the firft, he proceeds thus to the defcription of the laft.

Their formation.

All animal bezoards are compofed of concentric ftrata, fome have, at their centre, a foreign body, the nucleus around which the firft ftratum is formed; in the oriental various fubftances form this nucleus, fuch as marcafite, talc, flints, gravel, ftraw, grafs, wood, feeds of plants, cherry ftones, thofe of the caffia, tamarind, &c. Thefe different fubftances, and principally the feeds of plants, which are in the centre of the oriental bezoards, afford reafon to believe that they are formed in the ftomach or inteftines of animals. Their nuclei, according to Daubenton, fhow the impoffibility of their being formed in any other parts of the body from their difficulty of penetrating there: on the contrary, thofe fubftances may eafily enter the alimentary canal with

the food; and this hiſtorian has found in the paunch of oxen, after diſſection, great numbers of gravel ſtones, which might have become the nuclei of the bezoard.

Bontius ſays, that the oriental are formed in the bellies of animals, of which there are numbers in the different provinces of Perſia. Kæmpfer, who inquired in Perſia in what parts they are found, relates, that it is in the pylorus or the bottom of the fourth ſtomach; that if their origin is not there, the bezoard at leaſt remains ſome time in that ſituation, where it increaſes in ſize, and that if it be not prevented by the plaits of the ſtomach, it paſſes through the inteſtines, and is excluded with the excrements; but this acount is without proof, no obſerver having as yet opened an animal that contained theſe calculi, ſo as to be able to determine their ſituation. Kæmpfer has only related what he has heard.

The obſervations of Daubenton on the formation of theſe calculi induce him to think they originate in the ſtomach and inteſtines. He has remarked on the dentes molares of the ruminating tribes, a ſtratum of blackiſh ſhining matter, of an external brilliancy reſembling gilt or bronze, and in thoſe places where this matter is thick, it covers a whitiſh tartar. He had likewiſe obſerved a ſimilar matter on many occidental bezoars, and poſſeſſing the ſame brilliant gilt hue, and this ſtratum he thinks could only proceed from the herbs, the expreſſed juices of which became attached to the teeth during maſtication, and from a ſort of tartar analogous to the concrete juices of crude vegetables which they eat. He thinks there is no doubt but that the ſame juices which become thick and hard on the teeth, do the ſame on the external ſurface of the ſtrata of theſe bezoards in the ſtomach and inteſtines, ſince the gilt and bronze are ſimilar on both bezoard and teeth. The oriental bezoards are without theſe, but their ſurface is as ſhining as the mat-

ter that covers the teeth, it has the ſame ground of colour, and their ſubſtance appears to have a great relation to the concrete juices of plants; the ſtrata are of different thickneſs, but almoſt all of them have the ſame poliſh on their external ſurface.

The form of this calculus depends upon it's nucleus; they are generally more or leſs round when compoſed of a ſmall number of ſtrata; ſome are oblong, angular, and very irregular.

When a bezoard ceaſes to acquire new ſtrata, the more convex parts of thoſe already formed become worn, which appear then like an agat-onyx, but loſe nothing of their hardneſs in the body of the animal, although Kæmpfer aſſerts that it is neither hard nor ſolid in the animal. He appears to have been better informed when he attributes the difference of formation of it to the quality of the herbs which the animal takes in as nouriſhment; for the glutinous, aromatic, reſinous plants, growing upon the elevated parts of the hot countries, muſt receive from the ſoil, the air, the action of the ſun, juices proper to form the oriental bezoards. The ſubſtance of the body alſo contributes to this, ſince it does not appear, that every ſpecies of animal produces bezoards, even in hot climates. This bronze only covers the ſtrata of the occidental, and does not penetrate their internal part, or at leaſt it does not carry with it it's brown colour as in the oriental, for the internal ſubſtance is white or yellowiſh; the cryſtallization of this occidental bezoard is very regular, for if one of the ſtrata be broken, ſmall tranſverſal ſhining cryſtals appear, which are found to be cryſtallized needles directed from within, externally. The largeſt extend from one ſurface to the other, and between them are ſmaller, appearing like branches of the larger; they are all ranged tranſverſely in ſmall whitiſh lines, placed very near each other, and parallel to the ſides of

the ſtrata; thoſe which croſs the ſtrata, and which are themſelves croſſed by parallel lines, Daubenton thinks, may make the diſtinguiſhing character of the occidental, found in the ſtomachs or inteſtines of ruminating animals.

Having thus given the principal outlines of the ideas of Daubenton, reſpecting the formation of this calculus, there remains to add to what Fourcroy has given us on this ſubject ſome obſervations, from which it follows, that, Fourcroy's account of them.

1ſt. The bezoard is only found in abundance in animals of hot climates, thoſe which inhabit the temperate zone are more ſubject to ægagropilæ.

2d. It is only in the ſtomach and inteſtines of frugivorous or herbivorous animals that bezoards are met with, the carnivorous claſs being exempt from them. The concluſion, however, of ſome authors is erroneous, who think they are always to be looked upon as the reſidua of vegetable nouriſhment.

3d. If, according to this idea, more virtues are attributed to the oriental, on account of the herbs that grow on the mountains of Aſia, it is erroneous, there being plants in America as aromatic and ſharp as in the Indies, and the bezoards conſequently ought to partake of their virtues.

4th. Inſtead of looking upon them as the reſidua, they ought to be conſidered as concretions of the different ſaline ſubſtances depoſited, and more or leſs cryſtallized in the different cavities of animal bodies, according to the nature, properties and quantity of the liquids which held them in ſolution.

5th. Bezoards not only appear to differ in their nature, according to the ſpecies of animals that produce them, but they are eſſentially different from each other in the ſame animal, according to the places they occupy. The ſame takes place in the human body; the calculi found in

the gall bladder are very different from thofe found in the kidneys and bladder.

6th. The pretended method of diftinguifhing the true from the falfe bezoard by the grenifh trace on paper covered with cerufe or white lead, is not founded on fact; the falfe, if they contain only animal matter, will do the fame, as it arifes from the fulphureous hydrogen gas difengaged by the putrid fermentation.

7th. The bezoard, although the oriental is ufed in medicine, has not as yet been chemically examined; the bezoards of vegetables ought likewife to be more attended to. It is well known that the bamboo often contains a concretion called tabafheer by the Arabs, which feveral Englifh have found to be compofed almoft entirely of filex.

Fourcroy has feen in the cabinet of Juffieu, white, yellowifh, or milky fpheroid bezoards, polifhed on their furface, and fimilar to ivory; he was told they were produced by the cocoa; but nobody has yet inveftigated the vegetable bezoards, a great deal is therefore wanting before we can arrive at any perfect knowledge of thefe animal concretions.

Dr. Pearfon.

Dr. Pearfon, who examined one of the oriental fpecies, found it to confift of vegetable matter only.

Three kinds.

Calculus inteftinalis. This fpecies of concretion is found in the inteftinal canal of both man and beaft, and may be diftinguifhed into two kinds, according to the cavities in which it is formed. The firft comprehends thofe which, having been formed in the organs or vifcera adjacent to the inteftinal canal, have defcended into it by means of ducts communicating with it.

2d. Thofe immediately formed in the inteftines. Befides thefe two, perhaps a third fort may be admitted, or thofe which after having been in the adjacent vifcera and

depofited in the inteftines, have, during their abode there, been covered with a ftrata of concrete matter proceeding from the liquids contained in the inteftines.

The firft are almoft the only concretions found in the human fubject; they are almoft all of them biliary, which, after having been formed in the gall bladder, defcend by the ductus coledochus, where they remain more or lefs time, although in general they are immediately carried off by the anus.

The fecond, or thofe formed by the induration or cryftallization of the juices contained in the inteftines, are in the human body extremely rare. They are found not uncommon in other animals, and horfes are very fubject to them.

One of thefe was examined by Fourcroy; it was found in the colon of a horfe that had died of the gripes, in the year 1785; it's analyfis prefents fome curious facts. Cal. int. of a horfe, analyfed by Fourcroy.

It was of a gray colour, it's external furface appeared to be formed of rays diverging from the centre to the circumference, it's form was pretty regularly round, it's diameter five inches, and weight five pounds; when cut in two, the parts that formed it arofe from a common point the centre, diverging every way fo as to form a fphere of eighteen inches in circumference. The centre of this fphere prefented fome cavities in which were to be obferved fragments of vegetable matters, hay, ftraw, oats, which exhaled the odour of thefe fubftances when fomewhat changed.

It was infoluble in cold water, even when reduced to a fine powder.

In boiling water, this powder, however, was flightly foluble, and from it's analyfis this chemift concludes, that it was a triple falt compofed of about two parts of phofphat of magnefia, one part of phofphat of ammonia, and one part of water. In accounting for the formation

of this calculus, he conjectures that the magnefia, which is fo rarely found in animal matters, might have been introduced into the animal when adminiftered as a remedy in fome diforder, and by meeting with the phofphoric acid, and phofphat of ammonia, gave rife to this infoluble triple falt which formed this calculus; for this, however, to have taken place, the magnefia muft have remained a long time in the canal, and the animal muft have been a long time without rendering his excrements.

By Bartholdi. The analyfis of Bartholdi, upon a calculus of the fame fpecies, perfectly agrees with that made by Fourcroy. It was found in the rectum of a horfe, and an account of it is given in a letter to Vauquelin. He fuppofes it to have been found in the colon, and not to have been depofited in the rectum but a few hours before it's death. The animal belonged to a miller, and died of the gripes. It weighed about thirty-one cunces and half. It's form was round, oval, depreffed toward it's edges, and rather dented on one fide.

It's fpecific gravity was to that of diftilled water, as 16667 to 10000, and that of a detached portion as 16700. It was of a brownifh gray colour; it's diameter in length four inches two lines, and in breadth three inches. Being cut in two, it appeared compofed of many fpherical ftrata, between the firft and fecond of which was found an interftice of one line in breadth, and ten long, or rather in circumference, filled with bran and earthy matters. On the fame fide was obferved a flight dent. Half being again divided, the principal ftrata appeared to the number of eight, fome of which were compofed of thinner layers, but fo well united as not to be feparated without breaking the principal; each of thefe was compofed of fmall cryftals placed vertically. In the centre was found a fmall plate of iron, very thin, and about two inches in circumference.

It was completely ſoluble in the ſulphuric, nitric, and muriatic acids; without any effervefcence, likewiſe in diſtilled vinegar at the common temperature, a little reſiduum remained. The phoſphoric acid, when pure, and prepared by a flow combuſtion, entirely diſſolved it. Water had no effect upon it. From it's analyſis, it was found compoſed of

0, 18 of white magneſia.
0, 26 of phoſphoric acid.
0, 032 of ammonia.
0, 46 of water.
0, 04 of animal matter.

This chemiſt obſerves, that the facility with which the acetous acid diſſolves it, preſents a method of cure by glyſters of vinegar, which at leaſt are harmleſs. It has been ſaid that theſe calculi are principally found in horſes uſed by millers, and this chemiſt thinks that the bran, as a food, may have ſome effect in producing them, ſince this always afforded him magneſia; but whether their formation is owing to this ſkin of corn, or other grain, or to the earthy parts detached from the millſtones in the act of grinding, being compoſed of granite that contains white magneſia, has not as yet been aſcertained. Method of cure.

Calculus ſalivaris. It is not uncommon to find hard ſtony concretions in the ſalivary glands, particularly in the parotid and ſublingual. The calculi formed in the firſt glands have been known to deſcend into the duct, and produce a ſwelling, an abſceſs, and in conſequence, a ſalivary fiſtula; whilſt thoſe in the ſecond glands are ſaid ſometimes to form abſceſſes, by which means they eject themſelves. The authors who have deſcribed theſe diſeaſes, have in general attributed the origin of the calculi to a thickening of the ſaliva, or the coagulation of this *animal fluid,* as ſeveral have expreſſed it. Authors on the ſubject.

Haller, in treating of the nature of the faliva, admits with Fauchard, that the earthy fediment it contains is the fource of the cruft of the teeth, commonly called tartar; and adds that the falivary calculi, which he attributes to the fame matter, are fo frequent in the duct of the maxillary gland, that it would be difficult to find in the human body a part more fubject to calculi. He fupports this affertion upon the teftimony of Severin, Meibomius, Hagedorus, Eller, Kramer, Slevogt, Walter, Van Swieten, and Scherer, the laft of which authors has written a particular differtation on this fubject. Haller has feen the ranula, a diforder which confifts in the inflammation and confequent abfcefs of the neighbourhood of the frænum linguæ, produced by a falivary calculus in the duct, and cured by the extraction of the calculus; and feveral authors give accounts of the production of the angina from the fame concretion. Hippocrates, in the fecond book of his Epidemics, had already made mention of fmall ftones fituate under the tongue, confequently falivary calculi muft have been known to him; but no one had examined their nature, or even attempted the flighteft chemical inveftigation of their properties, until Fourcroy, on making fome experiments upon the tartar of the teeth, found, that this folid depofit was of the fame nature as the bafis of the bones; and this has fince been confirmed by Dr. Wollafton, who informs us that the two fpecimens of this incruftation which he examined, confifted of phofphat of lime, with a very fmall excefs of the earth. It appears that the human falivary calculus is the only one that has as yet been analyfed, and there remain thofe found in the glands of other animals, as the horfe, ox, fheep, &c., before any thing complete can be looked upon on the fubject. The nature of thofe in the amygdala is entirely unknown.

Tartar of the teeth examined by Fourcroy and Wollafton.

Calculus muſcularis. Theſe are granular concretions, angular, or irregular in their form, ſituated between the fleſhy faſciculi; they are rarely to be met with, and appear when they do exiſt to be in conſequence of arthritic diſeaſes of long ſtanding; but they are ſo ſcarce that Fourcroy was not able to procure a ſingle ſpecimen. Beſides theſe which may be called *muſcular calculi*, the fleſhy parts are liable to be affected by oſſeous concretions, as is often the caſe in old animals, when the extremities of the tendons and the ſides of the ſanguiferous veſſels become partakers of the ſame diſeaſe.

Theſe *oſſifications* have been examined by Dr. Wollaſton, who found, that what he procured from the arteries and valves of the heart conſiſted of the ſame principles as the earth of bones, and retained in like manner the redundant calcareous earth, on which account they are very properly called oſſifications. This chemiſt looks upon thoſe of the veins, the bronchiæ, and of the tendinous portion of the diaphragm, to have the ſame exceſs, although his experiments upon them were made too long ſince to ſpeak with any certainty.

Calculus pancreaticus. Theſe concretions have been found in the human pancreas, and are ſaid to bear a great reſemblance to the ſalivary concretions.

Calculus pulmonarius. According to Fourcroy, it is not uncommon to ſee patients, after a cough of long ſtanding, and particularly old people who have been very ſubject to arthritic affections, expectorate concretions from the lungs in very ſmall pieces; and ſimilar ones are found ſometimes in the lungs of thoſe who have died in conſequence of complaints of that organ, or from ſcrofulous affections. On cutting into the lungs, they are eaſily perceived by their grating noiſe againſt the knife.

Calculus uterinus. Hard concretions have alſo been met with in the uterus, which are looked upon as real

calculi. Thefe, however, have no relation, nor are to be confounded with thofe irregular maffes that go by the name of falfe conceptions.

Haller's Phyfiol.—Macquer's Wœrterbuch von Leonhardi, article Blafenftein. — Tyfchen's Unterfuchung eines Blafenfteins. Crell's Annal. t. 2. 1786.—Scheele's Effays.—Encyclopédie Méthod.—J. Hartenkeil, præs. Cafp. Siebold, de Veficæ urinæ Calculo. Vincebur. 1785.—On Gouty and Urinary Concretions, by Wm. Hyde Wollafton, M. D. F. R. S. Philofoph. Trans. p. 386. part. 2. 1797.—Experiments and Obfervations on the Compofition and Properties of Urinary Concretions, by George Pearfon, M. D. F. R. S. Philofoph. Trans. p. 15. p. 1. 1798.—Analyfe de Calculs, par A. F. Fourcroy. Annals de Chimie. vol. 16, p. 63.—Baillie's Morbid Anatomy. — Bartholdi, &c. Ann. de Chim. v. 23, p. 123.—Obfervations fur la Nature du Calcul de la Veffie, par le Cit. Brugnatelli, ibid. v. 28, p. 52.—Lettre du Cit. Fourcroy au Cit. Giobert. ibid. v. 30, p. 57.—Sur l'Analyfe des Calculs urinaires humains par les cit. Fourcroy and Vauquelin, Annal. de Ch. No. 95, p. 213.—Sur un Calcul urinaire de Cochon, &c. par le cit. Bartholdi, ibid. p. 185.

CALCULUS BILIARIS, BILIARY CONCRETIONS, OR GALL STONES.

These are light inflammable concretions, found in the gall bladder, and evacuated along with the fæces. They are produced by the gall in a diseased state of that excretion, and particularly in those diseases which some physicians have called spasmodic, in hysteria, and melancholy. These, by detaining the gall in the bladder, are said to give rise to these concretions. They likewise are the cause of other diseases, particularly the jaundice, and appear to be, with respect to the above viscus, what the vesical calculus is to the bladder.

The lightness and inflammability of gall stones, have been long known. Glisson, Bianchi, Hoffman, and others, have described some of their varieties and properties; but the first who attempted to arrange them methodically, was Walther, a celebrated anatomist of Berlin: he has divided them into three classes, after the method of naturalists; 1. lapilli striati; 2. lamellosi; 3. corticati. Vicq d'Azyr has likewise made an arrangement into three classes. In the *first*, he has placed those biliary calculi formed of a yellowish bilious matter, whether filamentous or not. The *second* contains those composed of a more or less shining crystalline matter, with or without a covering; and in the *third*, he puts the mixed calculi, or those in which the yellow bilious and crystalline substances are found united.

Arrangement into classes by Walther and Vicq d'Azyr.

There is a great variety in the external appearance of gall stones, as they not only differ in their colour, but in their shape. Some are of a white colour, others black; some are yellowish, others greenish, and others are of a

light brown, a dark brown, or a reddiſh brown colour; the different ſhades between theſe are likewiſe numerous, and not eaſily to be expreſſed. With reſpect to their ſhape, there is alſo a great difference, ſome being very ſmooth, others rough and tuberculated, ſome are roundiſh, others oblong, and angular. They alſo differ in their ſtructure, although when cut or broken, they are generally found to conſiſt of concentric laminæ externally, and in the centre are of a radiated texture. The laminated part, according to Baillie, bears ſometimes a large proportion to the other, whilſt at other times the contrary occurs. The laminated and radiated ſtructures are ſometimes compact, and at other times conſiſt of a looſe matter, whilſt it occaſionally happens that both theſe ſtructures are very obſcure, and they appear to be a very uniform ſolid maſs. The laminated part likewiſe on the outſide, very frequently conſiſts of a different ſubſtance, in appearance, from the radiated ſtructure in the centre, and it is not unuſual, as Baillie affirms, to find the ſtructure in the centre to conſiſt of ſhining white cryſtallizations, which have a good deal the appearance of ſpermaceti.

With reſpect to their taſte, very few, according to the obſervations of the above author, have a bitter ſavour, which is a reaſon he thinks that they do not conſiſt of inſpiſſated bile; in ſome, however, he found the ſavour intenſely bitter.

From the great variety of appearance which theſe calculi aſſume, it is evident the difficulty of arranging them into any method muſt be great; but Fourcroy, to whom we are indebted for the beſt analyſis, has divided them into three varieties.

Divided into three varieties by Fourcroy.

1ſt. Thoſe of a brown or blackiſh colour, with irregular or tuberculated ſurfaces, and formed as it were of lumps.

2d. Thofe which are yellowifh or greenifh, harder in their texture than the laft, formed of concentric ftrata, and often covered with a dry uniform cruft; the fhape of thefe is generally angular and polyedrous.

3. The laft variety comprehends the white and ovoid concretions, which are more or lefs irregular; they are covered with a whitifh, and often unequal rind, and formed, as it were, of fpathic ftrata, or tranfparent cryftalline lamellæ, and are often radiated from the centre to the circumference.

Befides this divifion of gall ftones, from their external and internal appearances, he has likewife diftinguifhed them according to their chemical analyfis, or the proportion of the principles of which they are formed, into two fpecies, viz. into thofe which are compofed only of a fhining, foliated, cryftalline fubftance analagous to fpermaceti, and into thofe which contain, with a more or lefs quantity of this cryftalline fubftance which appears to form the bafis or kernel, a thickened bile or extract, in the midft of which the firft fubftance appears to have been confufedly cryftallized. And into two fpecies from their analyfis.

Gall ftones are fpecifically lighter than water, and fwim upon it's furface; fome, however, are found to be fpecifically heavier, but of thefe there are very few. One that Gren weighed was to water as 0,803 to 1000. Sp. gr.

Expofed to the flame of a candle, they melt like wax, and become inflamed, but do not fmell like any of thofe animal parts that afford a volatile alkali by diftillation. Baillie, however, met with a very black fpecies that did not melt, but burned exactly like a cinder. Inflammation.

By dry diftillation in a retort to which a pneumatic apparatus was adapted, we are informed by Gren, that fome hydrogen and carbonic acid gas was obtained, and a yellowifh empyreumatic fluid of a bitter favour, that fcarcely reddened the tincture of litmus, did not precipi- Diftillation.

tate limewater; and on the addition of a fixed alkali, volatile alkaline fumes were extricated: there arofe likewife a brownifh empyreumatic oil. Teichmeyer received a yellow, then a red, and even a black empyreumatic oil. The remaining coal Gren found to amount to $\frac{1}{10}$ of the weight of the gall ftone; it was of a fhining appearance, of a blackifh colour, extremely difficult to incinerate, and being diffolved in nitrous acid, was found to be phofphat of lime.

Water. According to Haller, very few fhow any folubility in water, even when it is impregnated with fixed air; fome, however, as Hildebrandt obferves, communicate a bitternefs, and a little colour to the water in which they are boiled, although no folution takes place.

Vitriolic acid. According to Gren, pure vitriolic acid, when concentrated and added to pulverized gall ftone, became very warm, fulphureous gas arofe, the mixture affumed a dark brown colour, and on repofing, the gall ftone fwam on the furface in a fluid ftate, as long as the heat lafted. On being ftirred, there was no folution, but in a few days after the gall appeared like a black refinous coagulum, exactly in the fame manner as with fat vegetable oils, or animal fat. The decanted acid, on the addition of much diftilled water, let fall a gray flocky matter, fimilar to coagulated lymph. Delius found that the diluted mineral acids had no menftrual effect on gall ftones, yet the vitriolic acid as well as the muriatic received a green tinge. Baillie found, that they feparated in this acid into a fine black powder, efpecially in a fand heat. According to Hildebrandt, they detonate with nitre very ftrongly.

Nitre.

Nitrous acid. The concentrated nitrous acid became very hot, as Gren informs us, on the addition of pulverized gall ftone, and attacked it, which gave rife to a large quantity of nitrous gas. In this acid fome are entirely diffolved, others not, but melt to a yellow oil, which fwims on the furface

during the heat, and on cooling become coagulated to a yellow ſubſtance like wax. The decanted acid, Gren found, on adding much diſtilled water, let fall the diſſolved albumen in the ſtate of flocks. Hence it appears, that they conſiſt of a coagulable lymph, and a ſubſtance ſimilar to wax. Delius found, that this acid became of a red colour on their addition: Hermbſtadt, that diluted nitrous acid had likewiſe a menſtrual effect on them by the aſſiſtance of heat, and afforded ſaccharine acid; and all that Baillie examined were ſoluble in this acid.

Gren found, that by the uſe of concentrated muriatic acid the flocks ſeparated the beſt; whilſt Baillie found, that they are but little effected by it in a ſand heat. Limewater, according to Whytt and Gren, does not diſſolve them. Muriatic acid. Limewater.

From the experiments of Delius, it appears, they are very little or not at all ſoluble in carbonated alkalis; whilſt Hildebrandt affirms, that the lye diſſolves moſt of them. They are however, eaſily diſſolved in cauſtic alkalis, particularly by the aid of heat. Alcalis.

Neutral ſalts, as well as ſoaps, have no effect upon them, in which the experiments of Conradi agree with thoſe of Gren. Neutral.

All oils, whether fat or æthereal, as they have been called, and particularly the oil of turpentine, diſſolves them by heat. Baillie found, that moſt gall ſtones were ſomewhat ſoluble in the oil of turpentine at the heat of the atmoſphere, but not in any conſiderable degree; and one ſpecies he found inſoluble; ſome were converted into a kind of oil, that ſunk to the bottom; others that were partly ſoluble tinged it of a brown colour, and were partly ſeparated into a powder. Oils.

According to Baillie, gall ſtones are but little affected in the common temperature of the atmoſphere by alco- Alcohol.

hol, but are either partly or totally ſoluble in it at a boiling heat. Gren affirms, they are not diſſolved by the higheſt rectified ſpirit of wine, and that the extraordinary appearance the gall ſtone puts on in alcohol is not a ſolution, as many chemiſts have ſuppoſed. For inſtance, if pulverized gall ſtone be mixed with alcohol, then well ſhaken, and digeſted in a moderate heat, it will be found, on repoſe and becoming cool, to have formed uncommonly beautiful, ſhining, ſcaly cryſtals, which have the appearance of ſedative ſalt. According to Gren, this matter, which Poulletier de la Salle took for a ſalt, is nothing but undecompoſed gall ſtone, the parts of which being melted by the heat, puts on this beautiful cryſtallized appearance; for he found it was ſoluble neither in alcohol nor water, nor communicated to the laſt the leaſt trace of an acid or of a ſaline nature.

The production of a ſcaly cryſtallized ſubſtance.

As this ſhining ſcaly matter forms one of the moſt curious parts of the analyſis of gall ſtones, it will be neceſſary to give a circumſtantial account of it's diſcovery and properties. It was firſt obſerved, I believe, by Conradi, who extracted it by means of dulcified nitrous acid; then by Poulletier, by means of alcohol; and is found by Fourcroy to bear a great reſemblance in it's properties to ſpermaceti.

Firſt diſcovered by Conradi.

Poulletier.

Poulletier having examined the biliary calculi of the ſecond variety, obſerved they were ſoluble in alcohol. Having digeſted them with good ſpirit of wine, he remarked, that after a certain time this liquor was filled with very delicate, ſhining, cryſtalline particles, having all the appearance of a ſalt. His experiments on this ſubſtance gave him reaſon to ſuppoſe, that it was an oily ſalt, analogous in ſome of it's properties to the acid ſalt called the flowers of benzoin; but it appears, he knew nothing further of it's nature. This ſalt he thought was only contained in the human gall ſtone, as he was not

able to find it in that of the ox. This very ſingular circumſtance merits confirmation, for Fourcroy and Vauquelin have found a ſmall quantity of lamellated matter in the calculi of that quadruped.

The diſcovery of this matter has elucidated ſeveral facts that had been collected by the Society of Medicine at Paris, on the calculi of the gall-bladder. This ſociety received from it's correſpondents ſome of thoſe of the third claſs, which had not been deſcribed. They were maſſes of tranſparent cryſtalline lamellæ, reſembling mica or talc, and abſolutely of the ſame form as the matter extracted by Poulletier. It appears, that the human bile is capable of furniſhing a great quantity of theſe cryſtals, as the ſociety has in it's collection a gallbladder intirely filled with this tranſparent ſaline concretion. Fourcroy informs us, that he received from Lepreux and Halle, two bladders full, perfectly ſimilar, from which examination he found, they were of an oily nature, analogous to that of ſpermaceti.

Found to be analogous to ſpermaceti by Fourcroy, and forms a peculiar ſpecies.

It will not be improper to give a general view of the experiments that led Fourcroy to this concluſion, and may be found more in detail in the Third Volume of the *Anales de Chimie.*

He informs us, that more than twenty years are elapſed ſince the late Poulletier de la Salle, wiſhing to know the nature of biliary calculi, and determine their ſolubility in alcohol, from what Senac had told him was mentioned by Valiſneri, found, that theſe concretions depoſited, in proportion as the alcohol diſſolved the greateſt portion of them, a foliated, ſhining, lamellated ſubſtance, pretty ſimilar to the boracic acid. He was deſirous of ſeparating theſe cryſtalline lamellæ from the ſolution, and collect them upon a filter, but ſoon found they were ſo light, that although in appearance they occupied

a great ſpace in the ſolution, they were, on deſiccation, reduced almoſt to nothing.

The ſmall quantity he collected being put upon a hot coal, immediately diſappeared in ſmoke and vapours. This circumſtance was ſimply announced in Macquer's Dictionary of Chemiſtry; but Macquer did not ind[illegible], any more than Poulletier, the nature of this [illegible]ular ſub ſtance. Fourcroy having had frequen[illegible]caſions of making chemical experiments wi[illegible] Poulletier, and their converſation often turnin[illegible] on the ſubject of biliary calculi, Fourcroy fir[illegible]ays down the facts he learned from the la[illegible] chemiſt, and afterwards what he diſcovered himſelf reſpecting this peculiar ſubſtance, in the following manner.

1. The cryſtalline matter appears more ſoluble in warm than in cold alcohol; this warm liquor paſſes very clear through paper, but the matter ſeparates from it ſo readily, that Poulletier believed it to have paſſed with the alcohol. It is ſcarcely ſoluble in cold alcohol, *i. e.* a[illegible] ten or twelve degrees, as forty-eight grains were depoſited out of fifty on cooling, yet the liquor continued [illegible] depoſit a little on the addition of water.

2. This matter appears to vary in quantity in differnt human biliary calculi, though it conſtantly exiſts in a[illegible].

3. The proportion is very inconſiderable, for a few grains are ſcarcely obtained from a drachm of the ca[illegible]uli.

4. The calculi of quadrupeds, and particularly [illegible]f the ox, are ſoluble in alcohol, but contain no cry[illegible]alline matter. Theſe are the four facts which Fourcr[illegible] collected from Poulletier himſelf; he then gives an [illegible]ccount of his own diſcovery. It appears, that he had [illegible]ept for ſeveral years two gall bladders, abſolutely full [illegible] biliary ſtones; when in 1785, the diſcovery he ha[illegible]made on the oily nature of the dried liver, induced him [illegible] examine what might be the nature of biliary concretio[illegible]

The ſtones he made his experiments upon, were poliſhed, quadrilateral, lying on each other, externally gray, and internally of a brown green colour; he found that two pounds of alcohol were ſcarcely ſufficient by aid of a gentle heat to diſſolve two ounces of theſe pulverized calculi. The more hard and brown parts even refuſed. The warm ſolution when filtered was very clear, and of a yellow or ſlight green colour; on cooling, it quickly depoſited a great quantity of white brilliant cryſtals, reſembling thoſe of concrete boracic acid. This experiment proved this matter had been diſſolved by the warm alcohol, and was precipitated on it's cooling. Nearly one drachm of theſe cryſtals was collected on a filter, and had the properties of ſpermaceti, for which, *vide* animal oils. This proved to Fourcroy the great analogy between this and the dried liver, as well as ſpermaceti, and left him no longer in doubt but that it's ſource muſt have been in the liver itſelf. A third fact, as important as the preceding, proves the truth of it.

It is not many years ago ſince Walther, but more particularly Vicq d'Azyr, deſcribed with great care a peculiar ſpecies of biliary concretions, different from thoſe commonly found in the gall bladder, *i. e.* cyſtic calculi, rounded, or in polygons, formed of concentric ſtrata, gray externally, brown internally, but never ſo numerous in the bladder as the firſt; it has likewiſe never been found full of them, but on the contrary, with ordinary biliary ſtones, whilſt here rarely more than one is found, although more conſiderable in ſize than the common ones. Theſe ſolitary concretions are ſometimes as large as a pigeon's egg, but in general do not exceed the ſize of the egg of a ſmall bird. Their figure is nearly ovoid, ſometimes cylindrical, almoſt always rounded, but rarely unequal externally; their colour is white, on breaking; inſtead of brown concentric ſtrata or bile ſimply thick-

ened, and depoſited in ſtrata as in the moſt common of theſe calculi, they have a lamellated cryſtalline or ſtriated ſtructure, ſhining, white, ſoft and unctuous to the touch. Sometimes this concretion, inſtead of offering large plates of the ſize of it's diameter, only preſents ſtriæ. It alſo varies in colour, for inſtead of the white ſhining, ſilvery, or micaceous appearance, it is ſometimes yellow or greeniſh. It is often intermixed with brown bile in a maſs; a nut of thickened bile is always obſerved in it.

After Haller, who gave in a diſſertation in 1749 many facts on biliary calculi, we are informed by Fourcroy, that Walther has the beſt indicated the ſpecies under conſideration; but Vic d'Azyr has treated the ſubject with more care and exactitude than even Walther.

Vic d'Azyr, however, remarks with reaſon, that chemiſts as yet are not thoroughly acquainted with the nature of theſe concretions; he obſerves, after having deſcribed all the varieties, and as it were all the ſhades of theſe animal cryſtallizations, from the common biliary ſtone, even to that which is formed of this cryſtalline matter, that this laſt ſubſtance appears to be the ſame as that found by Poulletier de la Salle, in common biliary ſtones. In effect, it's chemical properties, according to Fourcroy's experiments, are perfectly analogous. Theſe cryſtalline biliary concretions become ſoft, and melt by heat like wax; but at a lower temperature, and abſolutely like ſpermaceti. They become fixed and cryſtallized on cooling. Water has no effect upon them. Hot alkali diſſolves them; whilſt a great part ſeparates on cooling in the form of brilliant talcy lamellæ. In a word, they preſented Fourcroy all the properties of the reſidue of the dried and putrid liver, and of the brilliant cryſtals which alcohol ſeparates from the calculi of thickened bile.

Gren analysed a stone which was of a yellow colour, and smooth to the touch, of a similar nature to those examined by Fourcroy; but Gren affirms that it was not soluble in alcohol, whilst Fourcroy was able to dissolve his in it with heat entirely. Gren concludes from his own experiments, that this gall stone was composed of eighty-five parts of cereous matter, and fifteen of lymph.

Remedies for the solution of biliary calculi.

It will not be amiss to terminate this article by some reflections on the use of taking internal remedies for the solution of biliary calculi.

None found in the ox, except in dry seasons.

Various medicines have been proposed to bring about their solution in the animal body; such as soap, a mixture of oil of turpentine and ether, &c.; without considering the decomposition which substances undergo when taken into the system, which prevents them from preserving their chemical action on the calculi, when out of the body; but it is an important and curious fact, that in the gall bladder of the ox no calculi are found, except after dry seasons, and from a want of fresh forage; and that during the spring and summer, when this animal is provided with plenty of green and succulent vegetables, they disappear. The butchers are well acquainted with this circumstance; they know it is from the month of November to March that these stones exist, and at this last epoch no more are to be found. Fourcroy is of opinion that this fact is sufficient to show the power of the soapy juices of plants in dissolving these calculi. The analysis of these concretions in the gall bladders of the ox and the sheep have not as yet been compared with the human, although they sometimes are found in large quantities, and the only use made of them has been in painting.

Calculus hepaticus. The bile, in a state of disease, not only gives rise to concretions which are found in the gall-bladder, but to others that occupy the interior of the

biliary veſſels of the liver; and although theſe are far from being uncommon, chemiſtry as yet has not attended to them. Theſe hepatic concretions are hard and ſolid, and perhaps on analyſis may be found to reſemble gall-ſtones in their compoſition.

Baillie's Morbid Anatomy. p. 156, 192. — Gren's Verſuche in Gott. S. Dieterich Diſs. contin. duas als. circa Calculos in Cyſt. hum. inventos. Hall. 1788.—Haller's Phyſiol.—Hen. Fried. Delius de Colelithis Obſervationes et Experimenta. Erlang. 1782.—Hildebrandt's Anfangſgrunde, &c.—H. F. Teichmeyer auct. et reſp. W. H. A. Strochlein de Calculis Biliariis. Jen. 1742. — Gren's Handbuch. — Hermbſtadt's Phyſiſch. Chemiſch. Verſuch. & Beobachtung.—Encyclop. Méthod. tom. 2. Chimie. p. 569.—Analyſe d'une Pierre retirée de la Veſicule du Fiel, par. M. Gren. An. de Ch. tom. 5. p. 186.

EXCREMENTS.

Whatever is ſeparated or excreted from the blood as uſeleſs, as well as the remnants of thoſe ſubſtances, both animal and vegetable, which after having undergone the proceſs of digeſtion, and ſupplied the body with nouriſh-ment, are only retained until there is an opportunity or neceſſity for evacuating them, may be called excre-ments.

Theſe are found either in a fluid or ſolid ſtate. The firſt comprehend the urine and ſweat; the ſecond, the feces.

URINE.

This fluid is an aqueous pellucid excretion, ſeparated by the kidneys from the blood of animals; it contains in ſolution ſeveral neutral ſalts, and ſome animal extractive matter, and is perhaps the moſt variable fluid of any in the animal body. It differs from all the animal fluids, by the preſence of a peculiar acid, by ſome called the lithic, by others the uric acid, from it's forming the baſis of ſome of the calculi of the bladder and kidneys; and it is alſo remarkable for containing a very large quan-tity of diſengaged phoſphoric acid, the phoſphats of ſoda, ammonia, and lime; but perhaps of all it's contents, the moſt curious is that lately found in it by Fourcroy, called ureè. Such are the principal matters contained in this excrement, the perfect analyſis of which is not per-haps at preſent attained.

Differs from other ani-mal fluids

Ancient opinions of it.

At the time of Pliny, the contents of th... ...id had not been inveſtigated, and even but few obſervations ha... ...en made on it's natural, ſpontaneous, and external changes. The ancients had, however, made ſome few remarks reſpecting it, both in a healthy and diſeaſed ſtate; thus they inform us, if the morning urine is white and clear, and the next after it higher coloured and inclining to a yellow, they conclude from the firſt, decoction was commenced, and from the ſecond, that digeſtion was perfect and completed. A red urine they conſidered a bad ſign, but a black one the worſt of all. Greeniſh urine betokened an obſtruction of ſome of the viſcera, and a heavy white ſediment was a ſign of ſome diſeaſe of the joints, or principal parts; if red, the blood was diſtempered; urine that contained matter reſembling bran, or had a black cloudy appearance, foreboded danger, but if it's contents were thick and fetid, it was conſidered as mortal. From this it appears, how little was known of this excretion at the time of Pliny, except what was expoſed to the moſt common obſervation; and even in this reſpect they were not fortunate in their remarks. Some ridiculous remedies were likewiſe aſcribed to it, which, in ſome countries, common ſenſe has not yet got the better of.

We need not be ſurpriſed at the ignorance of the ancients reſpecting the knowledge of the contents of this fluid, when we conſider how ſmall has been the progreſs of inquiry, and how imperfectly they have been examined, even in modern days. A number of writers, ſuch as Van Helmont, Henckel, Stahl, Binninger, Boerhaave, Margraaf, Willis, Pott, and Langriſh, had made us acquainted with ſome of the products obtained from it by diſtillation, and expoſure to different degrees of heat; but the method of examining this excrementitious fluid by reagents was reſerved for the preſent period; and it

Moderns.

is to Rouelle, Prouſt, Scheele, Halle, Brugnatelli, Berthollet, Cruickſhank, and more particularly to Fourcroy and Vauquelin, that we are indebted for a more exact analyſis and more extenſive obſervations on the ſubject.

Three ſpecies of urine have at preſent, however, only been ſubmitted to chemical analyſis, viz. the human, that of the horſe, and of the cow, to which Rouelle has added a very few remarks on that of the camel; but as the firſt has been more particularly the object of inquiry, and as it's importance far exceeds any thing to be derived from the others, it will form the principal part of this article. Three ſpecies examined.

Freſh human urine, of a healthy adult perſon, is a perfectly tranſparent aqueous fluid, of an amber or vinous yellow colour; it's ſmell is not diſagreeable; for when firſt voided it has a great reſemblance to that of violet powder, by which it is eaſily diſtinguiſhed from all other freſh animal ſubſtances. This aroma, however, only continues whilſt the urine remains warm; it often flies off in a few ſeconds, and the urine become cool, is ſucceeded by another, which is the true urinous ſmell. To the taſte it is ſaline and unpleaſant. Human urine.

A variety of circumſtances however makes it differ from this ſtandard, and the difference is ſtill greater when compared to that of quadrupeds. It's varie-

1. The age of the perſon from whom it is taken. In the fetus, it is without ſmell, little or no taſte, and almoſt perfectly aqueous. In childhood, the urine approaches nearer to that taken from the adult, and in old age, it is very ſharp or acid, of a diſagreeable ſmell, and very high coloured. Cauſes of them.

2. Whatever tends to increaſe or decreaſe the fluids of the body. Thus, a large quantity of cool drink, the cold of winter, repoſe, produce a pale aqueous urine in large quantity, having little odour or taſte; on the contrary,

a full meal of flesh meat, spirituous liquors, exercise, or whatever increases perspiration, as the heat of the summer, tend to make it high coloured, in small quantity, more saline, and to give it more odour of a disagreeable kind.

3. Affections of the mind. Thus, fear, and nervous weakness, as it is called, produce a pale inodorous urine, in large quantity, whilst vigour and strength, the contrary effect.

4. Certain kinds of diet give it a peculiar flavour, odour, and colour. Thus, asparagus, olives, garlick, onions, broom, endive, artichokes, horse-radish, and vegetables of other kinds that contain a strong essential oil, are said to communicate to urine their own peculiar disagreeable smell; whilst turpentine perfumes it with the odour of violets. Similar effects are mentioned by Galen and Dioscorides, who informs us, that the ancient physicians remarked, that the use of certain roots which they administered to their patients communicated a colour to their urine and excrements, and this observation has been repeated by Cardan, Thurneisser, Porta, Caster, Durantes, and others.

Macquer informs us, he has known persons accustomed to the headach and bad digestion, whose urine retained the most evident odour of the food, such as coffee, roots of various sorts, fruits, pulse, and even of soups and broths, particularly when made of the indigestible kind of meat, and in such urines he constantly found an acid immediately after evacuation. According to Plenck, an infusion of tea or of cassia fistula gives the urine a greenish colour; the fruit of the opuntia a red, and the rhubarb, a yellow colour. In the herbivorous animals it is found to be more or less fetid; in the carnivorous, sharp and acid, whilst some have pe-

culiar odours, as thofe of the cat, the fitchet, the tiger, &c.

Urine from it's putting on feveral appearances in the fame perfon when evacuated at different times has been called by phyficians under different titles. When evacuated an hour or two after taking in food, it is commonly very aqueous, and authors give it the name of *crude urine*; whilft that in the morning, which is high coloured, fomewhat acid, and thicker, from the more aqueous parts having been reabforbed, has the name of *urine of concoction*, from digeftion having been fuppofed to be over. Divifion of it into crude and concocted.

The fpecific gravity of healthy urine, according to Cruickfhank, varies from 1005 to 1033, diftilled water being at 1000; but the fubftances which form it's contents vary fo much in their proportions, even in the fame perfon, that it is extremely difficult to fix upon what may be confidered as a ftandard of the fpecific gravity of healthy urine. Specific gravity.

If frefh healthy urine be left to repofe in the open air; the changes it undergoes have been divided by Halle into four periods. It's changes on expofure to the air.

1. The firft takes it's rife with that of the *peculiar urinous fmell*, which is perceived a few hours after having been voided. Scarcely is the urine cold, before a turbidnefs appears, which is very flight, and coalefcing into a cloud, finks to the bottom. The urine is then clear again. This depofit is turbid, femitranfparent, whitifh, and refembles a very white jelly, of which it has all the properties, whilft Seguin affirms, that healthy urine contains no gelatin. This gelatinous depofit is only found in urine of decoction. In a day or two a fecond depofit takes place, which is faline: there is no apparent turbidnefs, but there arifes a more or lefs thick pellicle on the furface, whilft the internal fides of the glafs 1. Urinous period.

become more or lefs coated with a granular and cryftallized rind, fometimes of a whitifh, yellowifh, or of a red brick colour; at other times this variety of colour is obferved in the fame urine. In the laft cafe, the red cryftals being greater and more heavy than the reft, are the firft to fall down. Sometimes thefe two depofits take place at the fame time, but only, as Halle is of opinion, when in a difeafed ftate. By edulcoration this red part is deprived of it's colour. The pellicle only appears to differ from the rind by the mucus that unites it's particles. Sometimes the pellicle exhibits the colours of the rainbow, and is extremely thin and oily. They are both fandy to the touch, faline to the tafte, and fomewhat earthy.

2. Sour period.

2. Whilft the urinous fmell increafes, the urine becomes darker coloured, and the fecond period commences by a *four fmell*, refembling four broth, or the cafeous part of milk when turned. This four fmell does not take place in every urine, but is more peculiar to crude: in fome it is fcarcely to be obferved, in others, it will continue two or three or more days, and it rarely takes place before the third day. During this period, a white greenifh mould arifes on the furface of the pellicle, and the larger the quantity of mucus, the fooner it is perceived: it refembles that on the juices of vegetables, and folutions of animal jelly, and it takes place, although the veffel be hermetically fealed.

3. Alkaline period.

3. The urine being now of a red colour, the third period takes place by an evolution of *alkali*, producing the fmell of ammonia. There is a turbidnefs at the fame time, and a number of large and fmall flocks in it which caufe a third depofit, of an opake, white, fmooth matter, refembling marrow to the touch, and of an earthy rather than faline tafte: when this alkaline fmell is very ftrong, the urine becomes clear again, but grows darker.

This ammoniacal ſmell ſometimes immediately ſucceeds the ſour ſmell; at other times, there is an interval, when the laſt is only perceptible; and at other times, when there is no ſour ſmell, it is very evident on the third, and even on the ſecond day, but often not until the fifteenth or twentieth, or even later. It immediately deſtroys the mould. During this ſtage the urine effervefces ſtrongly with acid.

4. The urinous ſmell, which has been more or leſs perceived in conjunction with the alkaline or ammoniacal, is now deſtroyed along with it, by the fourth or *putrid period*. This is known by a nauſeous, cadaverous ſmell, the gelatinous parts of the ſediment become decompoſed, and are converted into a dirty gray, clotted maſs, which ends with the deſtruction of all the properties of the urine. When this putrid ſtench has ceaſed, the reſt is perfectly inodorous, the putrefactive proceſs being entirely over. It may be obſerved, that during theſe periods, the colour of the urine becomes changed, the principal varieties of which are, a gold yellow, brown yellow, reddiſh brown, red and dark brown, whilſt the taſte grows more ſharp and penetrating. We are informed by Rouelle and Halle, that crude urine is not ſubject to the putrefactive ſtage. 4. Putrid period.

Having examined the changes urine undergoes in it's ſmell, colour, and depoſitions when in a healthy ſtate, we are enabled by the obſervations of Brugnatelli to give ſome account of the colours and properties of the ſediment of urine in a ſtate of diſeaſe. The appearances the ſediment puts on in different diſeaſes are various; ſometimes it appears in the form of bran, or fine ſand; at other times it reſembles threads which have been taken for worms; ſometimes it appears in the form of a thick cloud, and at other times like pus. In Sediment of urine examined by Brugnatelli.

healthy people, the colour of the fediment is almoft always white, but in difeafe, it appears of various colours, fuch as gray, dark coloured, gold yellow, greenifh yellow, red and black. The moft ufual colour of the fediment of difeafed urine is red, fometimes of a pale brick colour, at other times fo deep as to furpafs the moft lively coloured cinnabar. The colour of the fediment is likewife fometimes quite oppofite to that of the urine. Brugnatelli has feen white, afh-coloured, greenifh and rofe coloured fediments in pale and yellowifh urines; and afh and amber coloured fediments in reddifh and deep red urine.

The colour accounted for.

This diverfity of colour has not been accounted for. Moft of the ancients attributed the colouring matter to the more or lefs changed ftate of the bile, and from this caufe they were of opinion, the yellow, yellowifh green, and the reddifh coloured parts of urine arofe.

Willis thought the amber colour in urine originated from the prefence of a kind of liver of fulphur. According to Brugnatelli, the red coloured fediment is owing to the blood; and he fupports his opinion, by afferting, that the high coloured fediment of a dropfical patient produced with an alkali a lixivium fanguinis that precipitated green vitriol of a blue colour, but that this was not the cafe with the white and afh coloured fediments. According to Scheele, the red colour is owing to the lithic acid. Hildebrandt is of opinion, the higher or weaker colour in urine moft probably depends on the greater or lefs quantity of carbon; and thefe two laft opinions appear the moft probable, fince the red coloured urines are more faturated with faline fubftances than the others, and particularly with the lithic acid; and it is well known, that when urine begins to corrupt the colouring matter is the firft that undergoes a change, paffing through different fhades until it becomes very dark

coloured, in which procefs the carbon acts a confiderable part.

Brugnatelli having collected the fediments of difeafed urine, extracted the faline particles by lixiviation with diftilled water, and dried the remainder in the open air. It was white, light and brittle, fhowed no difpofition to deliquefce, and had not the difagreeable urinous fmell as before. It afforded, when rubbed with lime, no trace of volatile alkali. Cold water converted it into a vifcous gluey fubftance, but did not diffolve it. It became however putrid in a warmifh air, and burned with a fmell of burnt hair to a coal. This fediment was diffolved by warm water, with the prefervation of it's colour. The red fediment that produced a red folution became yellowifh on the addition of nitrous acid, but refumed it's red colour again on adding fome alkali. Some of thefe folutions gave marks of a difengaged acid.

The fediment of healthy urine which fpontaneoufly feparated on repofe refembled that of difeafed. Lime water, fixed alkali, and folution of foap diffolve a little of thefe fediments. Acids, as the acetous, phofphoric and vitriolic, produce little or no change on them. Smoking fpirit of falt diffolved it perfectly when heated, and the nitrous acid, which acted even in the cold, raifed a thick, yellowifh fcum, that tinged the fkin yellow, and afterwards produced a beautiful fcarlet colour. By diftillation with nitrous acid, the acid of fugar was procured from the fediment. Such are the imperfect experiments of this chemift.

If firft healthy urine be fubmitted to diftillation not beyond a boiling heat, a mere water is obtained of a difagreeable fmell, which forms the greater part of the urine. It amounts to about $\frac{7}{8}$ of it, and is neither acid nor alkaline. The urine on continuing the evaporation, becomes browner and darker coloured, gets very turbid, and a certain quantity of an earthy looking pulverulent

Urine fubmitted to diftillation.

matter is depofited, that has been taken for felenite, but is the phofphat of lime or earth of bones, with a fmall excefs of acid. This falt is of difficult folubility, and is mixed with a little concrete lithic acid. On being evaporated to the confiftence of a clear firup, or cream, it is to be placed in a frefh place to cool, in order to obtain a cryftallization of the faline fubftances. The firft cryftals that appear are, according to Macquer, the *microcofmic falt*, known by the names of native or effential falt of urine, fufible or phofphoric falt; it is a faline fubftance, in brownifh prifmatic cryftals, compofed of two falts, viz. the phofphat of ammonia, and of mineral alkali; but according to Fourcroy, the firft cryftals are thofe of *marine falt*. By repeated evaporation and cryftallization, feveral fucceffive products of cryftals are obtained; afterward the lefs cryftallizable falts, as Macquer informs us, which are common falt, and digeftive falt of Sylvius, or febrifuge falt; the remainder is a brown, bitter, faponaceous extractive matter, which is looked upon as a fort of mother lye. The quantity of extractive matter is more variable than that of any other fubftance, hyfterical or crude urine containing fcarcely any of it, whilft that of concoction abounds with it. The moft frefh urine exhales by a fomewhat ftrong heat an ammoniacal odour, which Fourcroy thinks probably arifes from the decompofition of the phofphat of ammonia. By a ftronger heat, as the diftillation continues, the extractive matter affords water, containing the carbonat of ammonia, a part of which is likewife formed in a concrete ftate; a very fetid empyreumatic oil; and on the fire being pufhed as far as poffible, a little phofphorus is obtained, produced from the fufible falt that could not be feparated by cryftallization, and an animal coal is left of difficult incineration, in which is found a little muriat of foda; hence this extractive matter appears to af-

Extractive matter obtained.

ford nothing more than the ufual products of animal fubftances.

By a more exact analyfis of this extractive matter of urine, Rouelle difcovered that urine contains two fubftances in folution, which cannot be procured feparate by means of fire. By treating the foft extract by fpirit of wine, one portion is diffolved, whilft the other part remains untouched. He has called the firft, *faponaceous matter*; the fecond, *extractive matter*. Examined by Rouelle.

The *firft* he found to be faline, foluble in fpirit of wine, and cryftallizable, it is not, however, eafily dried on the water bath; it is deliquefcent, affords more than one half it's weight of ammonia, a little oil and muriat of ammonia. It's refidue changes the firup of violets green The *fecond* is foluble in water, but not fo in fpirit of wine; hence it refembles the gummy and mucilaginous parts of vegetables, is eafily dried on the water bath, like their extracts; it is black, lefs deliquefcent than the former, and by dry diftillation affords the fame products as animal jelly. Rouelle obtained from one pint of urine, from one ounce to 1 ounce and half of extract; this urine, however, was voided after concoction; whereas the fame quantity of crude urine only afforded 1, 2, or 3 drachms. He likewife found thefe two matters in the urines of the cow, the horfe, and the camel, but the extractive matter of the human urine is in very fmall quantity. According to Cruickfhank, 36 oz. of urine yield a refiduum varying from 1 to 1 oz. and half. Saponaceous and extractive matters.

The analyfis of urine by thefe means fhows that it is compofed of much water, difengaged phofphoric and lithic acids, the muriats of potafh and foda, the phofphats of foda, ammonia and lime, and two peculiar extractive matters, which according to Fourcroy give this fluid it's colour. Component parts of urine.

Their proportions according to Cruickshank.

The relative proportions of the component parts of urine in a healthy ſtate, Cruickſhank is of opinion, may be nearly as follows:

	oz.	drac.	grs.
Of muriatic ſalts	0	1	0
phoſphoric	0	3	50
lithic acid and phoſphat of lime with exceſs of acid	0	0	25
animal extractive matter	0	3	40

The neutral ſalts, when purified by cryſtallization, are generally very fuſible. This however, depends upon the greater or leſs proportion of phoſphoric ſalts, particularly the phoſphat of ammonia, on which their fuſibility in a great meaſure ariſes. Sometimes inſtead of melting, this ſaline matter decrepitates when ſuddenly heated, owing to an exceſs of the muriatic ſalts, of which the muriat of potaſh is in general the moſt prevalent, and is eaſily diſtinguiſhed from the muriat of ſoda, by it's cryſtallizing in ſome degree on cooling, and by it's affording cream of tartar on adding acid of tartar. In recent urine, this chemiſt found, that the ammoniacal ſalts bear a very ſmall proportion, but when ſtale or putrid, they are, as may be expected, much more abundant. The phoſphat of ammonia is the principal, although the muriat of ammonia is likewiſe to be met with.

Putrid urine.

Urine is very much inclined to putridity, and under certain circumſtances, as in very warm weather, we are told by Macquer, that ten or twelve hours are ſufficient to produce it; if the heat be at the higheſt natural temperature, it will undergo this ſpontaneous decompoſition in five or ſix hours, or leſs; it then has a diſagreeable, ſtinking, ſharp penetrating ſmell, in which the ſmell of ammonia is very perceptible; urine being one of thoſe animal matters, from which this ſalt is extracted in the

greateſt quantity during the putrid ſtate. It now changes the ſirup of violets to a green colour, and gives, by diſtillation on the water bath, a volatile alkaline ſpirit, that has been called the ſpirit of urine, or ſpiritus urinæ. It would appear that the diſagreeable ſmell, which ariſes previous to the alkaline in theſe ſudden changes of urine, proceeds from this ſalt; for if an acid, ſuch as vinegar, be poured into urine which is beginning to ſtink, the ſtench is immediately deſtroyed together with the penetrating alkaline ſmell; on the contrary, if fixed alkali, or unſlacked lime be mixed with the freſheſt urine, it immediately gives riſe to the ſame penetrating putrid aroma.

Examined by Rouelle.

Rouelle, in his examination of the nature and proportions of the ſalts in putrid urine found no evident difference from thoſe collected from this fluid when freſh voided; however, in the ſaponaceous and extractive parts the change was conſiderable. According to Hildebrandt, foul urine does not afford ſo much fuſible ſalt as freſh, ſince, during the putrefactive ſtate, the ammonia is conſtantly eſcaping, leaving the phoſphoric acid behind. The ſame takes place likewiſe if putrid urine be evaporated in a water bath, to the conſiſtence of honey; in other reſpects, it does not differ from freſh urine.

Action of reagents on healthy urine.

Urine was formerly conſidered as an alkaline lixivium, until it was diſcovered that it always contained a diſengaged acid, in it's healthy ſtate, and when recent, for if it be kept any length of time, there is a production of ammonia; hence for examination it is requiſite that it ſhould be freſh voided.

Freſh, healthy urine reddens the tincture of litmus.

Acids produce no precipitation in it; the nitrous, however, cauſes an efferveſcence, and gives it a reddiſh colour.

Cauſtic vegetable and mineral alkalis, and quicklime,

when added to urine, produce an infupportable alkaline, putrid fmell, by decompofing the phofphat of ammonia. If a folution of volatile alkali be dropped into it, a flight cloud is produced, which is the phofphat of lime, two grains of which may be obtained from four ounces of urine.

Method of Berthollet to find the quantity of phofphoric acid.

Rouelle, Macquer, and Halle, having looked upon urine when frefh as not poffeffing any acidity, it was confidered in that light, until the more exact experiments and obfervations of Scheele and Berthollet proved the contrary. Scheele affirmed, that it contained not only the phofphoric but the lithic; but Berthollet proved that it was the phofphoric only, in a difengaged ftate, or rather combined in excefs with calcareous earth, and he has given us the following method of determining the proportion of this acid exifting in different urines, by means of limewater and ammonia. For this purpofe, a quantity of limewater is mixed with the urine, and the precipitate (from which phofphorus may be obtained) is to be collected on a filter. This precipitate arifes from the union of the lime with the excefs of the phofphoric acid, and confifts of the phofphat of lime naturally contained in the urine, and fufpended in it by excefs of the phofphoric acid, and that formed by the lime fuperadded to this excefs. Having likewife obferved, that ammonia precipitates the calcareous phofphat of lime by neutralizing the excefs of acid which held that falt in folution, he remarks, that the weight of this precipitate, compared with that produced by limewater, indicates the quantity of difengaged phofphoric acid contained in the urine; becaufe, in fact, the phofphat of ammonia formed in this experiment remains diffolved, whilft the phofphat of lime produced by the limewater, being infoluble, is precipitated at the fame time as the other portion of calcareous

By limewater.

And ammonia.

phofphat which naturally exifts in the urine. According to Bonhomme, the urine of infants contains no acid; but Weber has proved the contrary.

An infufion of tan or oak bark detects the gelatin, and the quantity of coagulum thrown down will, in general, bear a certain proportion to the extractive matter. From four ounces, Cruickfhank obtained four grains of this kind of precipitate. Action of tan.

Corrofive muriat of mercury has no immediate effect on urine. Urine, however, decompofes many metallic folutions. Lemery diftinguifhed by the name of the rofe-coloured precipitate a magma of that colour, which is formed when the nitrous folution of mercury is poured into urine. When the nitrat of mercury in folution is added to frefh urine, it produces a rofy-coloured precipitate, which is the phofphat of mercury, arifing from the decompofition of the phofphats in the urine. According to Fourcroy, this precipitate is formed partly by the muriatic acid, and partly by the phofphoric; and Brongniart has obferved, that this fometimes inflames by friction. According to Bonhomme, the nitrat of mercury has no effect on the urine of children; but in old people, it produces a very abundant precipitate, of a gray colour, which is the phofphat of mercury; hence he concludes, that the phofphoric acid increafes in proportion to the age, and confequently in proportion to the deftruction of the folids, which is operated by age. Muriat of mercury. Nitrat of mercury.

Muriat of barytes precipitates the phofphoric falts. By this method four ounces of urine produced a precipitate with it of 13 grains, which is equal, according to Cruickfhank, to about 24 or 25 grains of microcofmic falt, confifting of fuch a mixture of the phofphats of foda and ammonia as are ufually met with. This is therefore a teft that may determine whether thefe falts are deficient or in too great quantity. Muriat of barytes.

Sulphat of iron.

Sulphat of iron has a fimilar effect to muriat of barytes, but as a little excefs of acid might prevent the feparation of the phofphat of iron, it is not fo certain.

Acetite of lead.

Acetite of lead being decompofed by the muriatic and phofphoric falts, forms with the laft an infoluble precipitate, but the muriat of lead may be diffolved by 18 or 20 times it's weight of water. This reagent, therefore, gives a ready method, according to Cruickfhank, of determining their relative proportions; for if a given quantity of urine be precipitated by this fubftance, the precipitate dried, and digefted in 20 times it's weight of diftilled water, the remainder muft be phofphat of lead, and the quantity taken up will indicate the proportion of muriat of lead. Four ounces of urine gave a precipitate of 31 grains, feven of which were taken up by digefting it in diftilled water; the remaining 24 grains were found to be phofphat of lead, equivalent to 23 or 24 grains of microcofmic falt.

To difcover the lithic acid and phofphat of lime by Cruickfhank's method.

As the lithic acid and phofphat of lime are generally depofited, at leaft in great meafure, after the urine has become cool, and ftood for fome time, this chemift afferts, that they may be eafily diftinguifhed by diffolving them in twice their weight of nitrous acid diluted with a little water, and evaporated to drynefs; the mafs, when hot, will affume a beautiful deep rofe or crimfon colour, if the lithic acid be prefent, but will continue white although heated even to drynefs, or have only a flight greenifh tinge, when there is nothing but phofphat of lime.

And their relative proportions.

Their relative proportions may be afcertained by expofing the mixed mafs, for fome time, to a red heat in a crucible, when the lithic acid will either burn out or evaporate, leaving the phofphat in a pure ftate. The quantity of the firft was found to vary exceedingly, but the laft was in general nearly the fame, the proportion being about one grain to two ounces.

The urine may be confidered both chemically and medically, as a fluid containing the faline and other foluble parts, that are not only ufelefs in the animal machine, but which might hurt and derange it's functions, if not extricated from it; and fecondly, as an evacuation, the proportion of the principles of which, by varying with the ftate of the body, becomes a fpecies of meafure by which the degrees or modifications of health and difeafe may, in fome meafure, be known. It is found by experience, that the difengaged acids, and the phofphat of lime it contains in particular, undergo very fingular changes in difeafes of the joints and bones, as in the rickets, &c. A large proportion of faccharine matter is found in the urine in diabetes; and although numerous future obfervations are wanting, before an exact knowledge of the effects of difeafes on this fluid can be acquired, yet fomething may be gained, even in it's prefent infant ftate of inveftigation. For inftance, we are informed by Berthollet, that the urine of gouty and rheumatic patients habitually contains much lefs phofphoric acid than healthy urine; but during the accefs of the gout, a larger quantity than ufual (though not more than that of a ftrong perfon), and by making obfervations on the urine of a perfon very fubject to that difeafe, he was enabled, at length, to know with certainty by the quantity of acid in it, whether or not he had an accefs of the difeafe.

Urine confidered as a ftandard in health, and difeafe.

In order to diftinguifh the difference between healthy and difeafed urine, to find out the fhades in the proportions of their component parts, and to inveftigate the changes that have taken place, great affiftance may be had from reagents.

Infufion of tan or bark, as before obferved, is an excellent reagent to difcover the prefence of gelatin. In healthy urine, when the ftomach and digeftive functions

are daily exercifed, it is faid, that no precipitation takes place on adding this infufion; but in all gaftric affections, and in thofe difeafes where the urine is more or lefs charged with gelatin, it produces a greater or lefs abundant precipitation, and this happens in all cafes where the affimilating or digeftive powers are deranged or impaired, and wherever there are fymptoms of indigeftion. It likewife difcovers the ftate of this fluid in what have been called nervous and fpafmodic affections, at the approach of which the urine will be moft generally found tranfparent, large in quantity, and abounding in faline, but containing fcarcely any extractive matter. Similar appearances have alfo been obferved to precede delirium in fevers. This ftate may be difcovered by this infufion, with which it will fcarcely afford any precipitate; on the contrary, Cruickfhank found that the *acetite of lead* produced in thefe cafes a very copious precipitation.

Acetite of lead.

Nitrous acid.

The nitrous acid has much the fame effects as the muriat of mercury. In fome difeafes, however, particularly in dropfy or anafarca, this chemift found, that the nitrous acid produced a milkinefs, and in fome inftances a coagulation, fimilar to what would take place if added to the ferum of blood. In dropfy, the general difeafe may be eafily diftinguifhed from that arifing from a difeafed liver, or other morbid vifcus, both by this acid and the corrofive fublimate. In three cafes, Cruickfhank informs us, that the urine coagulated not only on the addition of this acid, but likewife by heat; and in one of them, that proved fatal in fix weeks, the urine appeared to differ but very little from the ferum of the blood, fo remarkable was the coagulation produced by heat and acids. On the contrary, in the dropfy arifing from a difeafed liver or other morbid vifcera, the urine does not coagulate either by nitrous acid or heat; it is ufually fmall in quantity, high coloured, and depofits, after ftanding,

a confiderable quantity of a pink-coloured fediment, which may be efteemed in fome meafure characteriftic of a difeafed, or rather a fcirrhous liver. On examination, it was found to confift of phofphat of lime, fome animal matter, and a little lithic acid; hence in morbid ftates of the urine, the coagulable part is detected by this acid, and even by heat.

It is now well afcertained, that the prefence of fugar may be detected in the urine of difeafed people, as in diabetes. Willis was one of the firft who found that this fluid, in a diabetic patient, was fweet and like honey; and Dobfon collected one ounce of faccharine matter from one pound of this kind of urine. Home informs us in his Chemical Lectures, that he brought this urine to ferment into a liquor fimilar to beer; hence he looked upon it to be of a vegetable nature, fuppofing no other animalized fluid capable of that fermentation.

Prefence of fugar in diabetic urine.

For the detection of fugar in urine, even in fmall quantity, Cruickfhank added twice the weight of nitrous acid to one of the extract obtained by evaporating fome diabetic urine; he then evaporated the whole to a very fmall quantity, and found, when cold, that if the cryftals formed in it be all of them cubes, or rhomboids, it is certain that no oxalic acid has been produced; but if flender needles or prifms be found along with them, they fhould be carefully feparated, dried on blotting paper, and thrown into limewater, and the precipitate, if formed, muft be either from phofphoric or oxalic acid; if it has the refemblance of flocks, and fubfides flowly, the phofphoric acid is the precipitant; if it has a powdery form, and fubfides quickly, it muft be produced by oxalic acid, for all animal fubftances, according to this chemift, do not yield oxalic acid; the extractive matter of healthy urine, and the pure coagulated part of the ferum of the blood being exceptions.

In confirmed diabetes the urine is ſweet; this chemiſt, in one caſe, collected by evaporation, from thirty-ſix ounces, troy weight, of urine, three ounces one drachm of ſaccharine extract, which, in the day, would have amounted to twenty-nine ounces. He likewiſe found, that this ſaccharine extractive matter, like honey, afforded no ſaccholactic acid by the nitrous acid, conſequently, that it does not contain it's baſis, which ſufficiently diſtinguiſhes it from the ſaccharine part of the milk of animals, and appears to prove, that it is nothing more than vegetable ſugar mixed with a greater or leſs proportion of animal mucilage. He found that two drachms of dryiſh and ſweet diabetic extract, yielded with twelve drachms of the nitrous acid from forty to fifty grains of cryſtallized oxalic acid, which is nearly the proportion obtained from an equal quantity of common ſugar, making allowance for the water and ſaline ſubſtances. The nitrous acid detects alſo a ſmall quantity of bile during the jaundice, by rendering the urine green, but this is better detected by the muriatic acid; when therefore the urine ceaſes to become green on the addition of either of theſe acids, it may be concluded, that the obſtruction to the paſſage of the bile into the duodenum is removed, and conſequently that the yellowneſs of the ſkin, &c. will ſoon diſappear; the ſulphuric acid, in ſome meaſure, produces the ſame effect, but the muriatic is preferable to either of the other two.

Action of the muriatic acid.

Sulphuric acid.

Muriat of mercury.

It has been obſerved, that muriat of mercury has no effect upon recent healthy urine, but it has been found very uſeful in detecting the condition of urine, accompanying the acute rheumatiſm, inflammation of the cheſt, and other inflammatory diſeaſes, immediately affording a greater or leſs degree of milkineſs, and a whitiſh precipitate during the active ſtate of the diſeaſe; when, however, the diſorder takes a favourable turn, this effect

will in great meaſure ceaſe, and a lateritious ſediment appears. The ſame happens in fevers accompanied with a ſtrong action of the veſſels; but in theſe caſes the lateritious ſediment, which never fails to make it's appearance at the criſis or abatement of the diſeaſe, is much more remarkable and conſtant, and the nitrous acid, when added to the urine before the depoſition takes place, gives it a pretty deep red tinge. Likewiſe in gout, the termination of the paroxyſms is moſt perfectly indicated by a copious lateritious ſediment, and when this ſuddenly diſappears, and the urine at the ſame time affords a precipitate with the muriat of mercury, a freſh attack or relapſe may be expected. This chemiſt generally found this ſediment to be compoſed of lithic acid, phoſphat of lime, and ſome peculiar animal matter, but little ſoluble in water. Some have ſuppoſed it to conſiſt entirely of lithic acid, but this generally conſtitutes the ſmalleſt part.

Bonhomme, who has examined the different ſtates of urine by the nitrat of mercury, and particularly the difference between the urine of old people and that of thoſe troubled with the rachitis, found that the firſt contained a much greater quantity of earthy depoſit and ſaline extract than that of younger ſubjects; and that with reſpect to the ſecond, the urine of theſe under this diſeaſe preſented an abundant and earthy depoſit, which differed in appearance from that of old people, affording no phoſphat of lime; it is alſo greater in quantity, one pound depoſiting two ounces, whilſt that of the firſt only depoſited forty-five grains. The extract from that in rachitis, left by evaporation, is larger in quantity, even by a third. Hence it appears, that the ſolids in rickets are deſtroyed more rapidly than in old people, and furniſh more abundant relics. Likewiſe the depoſit that lime-water occaſions in the urine in rachitis, is very inconſi-

Nitrat of mercury.

derable, of a brown colour, gelatinous when fresh, and powdry when dried; and does not resemble the phosphat of lime in any respect. Lastly, the precipitate formed by the solution of the nitrat of mercury is very abundant, never rose-coloured in rickety urine, as in that of adults, nor gray, as in that of old people, but always white; hence has no external relation to the phosphat of mercury. This chemist looks upon it to be an oxalat of mercury. When, however, the rickets was cured, the urine became again the same as that of healthy children, and this may be the means of knowing when this disease has submitted to the art of medicine.

Acetite of lead.

For the acetite of lead, *vide* the effects of tan on urine, in a diseased state. From these few and imperfect observations on the action of reagents on healthy and diseased urine, it may be concluded, that the importance of the subject demands a more extensive investigation; which, by affording a more perfect collection of facts, would be capable of greatly assisting the science of medicine.

Acids supposed to exist in urine.

As several acids and salts are related by some chemists to have been discovered in healthy urine, it may be necessary to give some account of those which this fluid has been supposed to contain, and the mistakes the investigation has given rise to.

Carbonic acid.

It was supposed by Dr. Priestley, that recent urine contained fixed air, as he had extracted from it about one fifth of it's volume of that acid: he, however, confesses, that not only heat was necessary, but even continued for several hours. Dr. Percival has published an account in the London Medical Journal, of having nearly saturated urine with fixed air, by merely drinking a sufficient quantity of water, impregnated with this gas: but the errour of these two philosophers has been proved by Morveau,

who has ſhown, that it was the phoſphoric acid, and in a diſengaged ſtate, as diſcovered by Berthollet.

In 1740, Haupt affirmed, that there was a peculiar ſalt in urine, which he diſtinguiſhed from the microcoſmic, by the name of *ſal mirabile perlatum*, and which in 1737 Hellot had previouſly found in priſmatic cryſtals, and looked upon as ſelenite. Pott, who had as well as Margraaf obſerved, that by a ſtrong heat, it afforded a white vapour and no phoſphorus, took it for a ſpecies of vitriolic acid, ſomehow connected with an alcaline ſalt. Rouelle calls it the ſel fuſible à baſe de natron, and looks upon it to be the animal or phoſphoric acid, united with natron for it's baſis : this celebrated chemiſt has deſcribed the proceſs of ſeparating it from all foreign matter, in a very exact manner.

In 1781, Prouſt undertook it's examination, but he denied that the acid was the phoſphoric, becauſe the ſubſtance when diſtilled in the dry way with charcoal afforded no phoſphorus. Having obſerved that it was decompoſed by vinegar, which deprived it of it's baſis, and which by repeated evaporation afforded the acetite of ſoda ; in order to obtain that ſubſtance pure, which previouſly neutralized the ſoda, he uſed alcohol in order to ſeparate the laſt portions of the neutral ſalt from the mother lye of the cryſtals. Having, therefore, cryſtallized the greater part of the acetite of ſoda, he poured on the mother lye eight or ten times it's weight of hot ſpirit of wine, agitated it ſtrongly, until the acetous ſalt was diſſolved, and a thick matter was collected at the bottom of the veſſel in the form of a *magma*. This matter was waſhed in freſh hot ſpirit of wine, afterwards diſſolved in diſtilled water, and afforded by ſpontaneous evaporation in the open air cryſtals, which this chemiſt looks upon as a body *ſui generis*, and which he places amongſt the ſimple ſalts, and compares to the acid of

borax. This ſalt was afterward placed by Bergmann amongſt the acids, in his Table of elective attractions, by the name of *acidum ſalis perlati*; and Morveau, who looks upon it not as a diſengaged, free acid, becauſe it changes the ſirup of violets to a green colour, thinks, however, that an acid is preſent, although the method of obtaining it has not yet been diſcovered. He is of opinion that it performs the function of an acid, ſince it unites to different baſes, which is ſufficient to give it a place in that claſs; and he has deſcribed it in the Encyclopédie Méthod. by the name of the *ouretic acid*. From the experiments of Klaproth, it has now been proved, that this ſuppoſed peculiar acid is nothing elſe than the phoſphoric, as Rouelle had already conſidered it, united to a little ſoda; and that the vinegar uſed by Prouſt only extracted a part of this ſoda; for if a ſolution of the nitrat or muriat of lime be poured into a ſolution of perlate ſalt, a precipitate of phoſphat of lime immediately takes place, and then the phoſphoric acid may be ſeparated by the vitriolic acid in the manner phoſphorus is made; and on the contrary, if pure phoſphoric acid be ſaturated with ſoda, it forms the real perlate ſalt, or acidum perlatum.

Perlate acid.

Acide ourétique.

Oxalic acid.

Another acid, that has been ſaid to exiſt in urine, is the oxalic, or acid of ſugar. Henckel had obtained ſmall white priſmatic cryſtals from ſome urine that had been kept well cloſed for three or four years, which have ſince been ſaid to be thoſe of the acid of ſugar, although others have expreſſed their doubts. Brugnatelli obtained an acid from the ſediment of urine, which Leonhardi looks upon as reſembling the acid of ſugar, but it was ſaturated with lime. It ſhot into quadrilateral white cryſtals, ſoluble in cold water, deliqueſced in the air, taſted ſour, and poſſeſſed all the common properties of an acid. It's ſolution decompoſed all calcareous ſalts, and precipi-

tated lime water, and vitriol of iron of a white colour. It was foluble in vitriolic acid, formed with potafh an orange-coloured faline mafs, which after edulcoration with water gave colourlefs, tranfparent, prifmatic needles in clufters, infoluble in cold and warm water, and expofed to fire left lime and alcali behind. The acid itfelf, likewife, after fwelling in the fire, left a white lime. That from the red fediment of urine alfo contained fome particles of iron. This acid, therefore, which fo much refembles the oxalic, was united with earthy parts in the fediment, and with ammonia in the urine. There is, however, every reafon to fuppofe, that whenever any faccharine acid has been met with in urine, it is in confequence of difeafed digeftion; for Scheele, who was a moft accurate and experienced chemift, found no fuch acid in healthy urine, but he obtained by fmoking acid of nitre what appeared to be the falt of benzoin, and which he fuppofed to be united with volatile alcali.

Acid of benzoin.

With refpect to the vitriolic acid, felenite and vitriol of potafh, as well as muriat of lime, and Glauber's falt, which Lauth thought he had found, they were only accidental; and his filiceous and argillaceous earths probably arofe from the utenfils he employed. The other fubftances, faid to have been found in this fluid, are fcarcely worth mentioning; Weftendorf and Gunther, however, thought they had difcovered a naphtha, and it was the opinion of the celebrated Bergman, that befides the different faline bodies, it contained a bilious, fat matter.

Other fubftances.

There are, however, fome well grounded fufpicions of the prefence of a peculiar fubftance, or rather acid in urine. We are informed by Cruickfhank, that if to an ounce of extract of frefh urine the fame weight of concentrated nitrous acid, diluted with an equal quantity of

Reafonable fufpicions of an unknown acid by Cruickfhank.

water be added, an effervefcence takes place with heat, and nitrous gas is difengaged; and in the liquor when cool, a number of fhining fcales or cryftals are depofited, refembling the acid of borax, which well dried weighs from five to feven, or more drachms. Their figure appears to be flat rhomboids, fmooth and greafy between the fingers, more foluble in hot than cold water, in fome degree in alcohol, and although repeatedly wafhed with this fluid and dried, they ftill retain acid properties, ftrongly redden violets, are eafily taken up by the acids of vitriol and common falt, without commotion, but effervefce with the nitrous, and form very foluble falts, the properties of which have not been fufficiently examined. Their folution in water does not precipitate limewater, nor the muriats of lime and barytes, nor the nitrats of filver or mercury, in any fenfible degree, nor has it any effect on the fulphur of iron or acetite of lead; they neither contain, therefore, phofphoric or oxalic acid; when thrown on a red hot iron, they melt and evaporate into a white fmoke, leaving a very fmall quantity of a charry refiduum, by no means difficult to incinerate, but when expofed to an intenfe heat, they burn with a reddifh flame, and a kind of detonation, fomewhat fimilar to nitrat of ammonia; hence, fays Cruickfhank, it would appear that this fubftance is an animal acid hitherto unknown, and whofe bafis exifts in this extractive matter.

By Dr. Gaertner.

Another teftimony of an acid in urine is Dr. Gaertner, who has been much employed in experiments on this fluid. He found, after a very rigorous examination, that the acid of urine, which he took for the phofphoric, only refembled it in a few properties, and that it poffeffed others totally different from all the acids. This acid is volatile, and expofed to a ftrong heat is fublimed in the form of flowers; the nitric acid does not convert it; the

nitric, muriatic, and fulphuric acids, precipitate it from it's alcaline and earthy combinations, partly in the form of gas, and partly under that of a fixed acid; it forms by evaporation a fcaly falt, which is not changed on expofure to the air, and which expands the odour of the gafeous acid. Dr. Gaertner afks, whether it may not hold the medium between the benzoic and lithic acids?

Difengaged phofphoric acid in urine.

The exiftence of the phofphoric acid, whether combined or free in urine, was unknown to the ancients; a few obfervations, indeed, on the effects of this fluid had been made, but they had no idea that it was owing to any particular acid, and it was not even fufpected to exift until the difcovery of the effential falt of urine, and of phofphorus, in which it exifts in a ftate of combination, (*vide* phofphoric acid). The difcovery of it's being prefent in urine, in a difengaged ftate, is much more recent. Rouelle had obferved, that at a certain time preceding putrefaction, this fluid changed the firup of violets to a red, and Macquer proved that the urine of thofe with bad digeftion reddened an infufion of litmus; but Berthollet, extending his refearches much farther, found that the urine of people who enjoy the beft health has the fame property; and that it depends upon the prefence of the phofphoric acid in a difengaged ftate. To be convinced of this, when lime water is poured into recent urine a white powder is depofited, which is the phofphat of lime. Berthollet is of opinion, that this acid becomes afterward faturated with the volatile alcali, formed by putrefaction, or the action of heat, which Morveau thinks may be admitted, without excluding the idea of a portion of it having been previoufly faturated with the fame bafis. Berthollet alfo remarks, that when lime water is poured into recent urine, it not only takes hold of the uncombined acid, but alfo

of that portion united to an alcaline basis, from it's greater affinity with lime.

Microcosmic salt.

The crystallized mass obtained on the evaporation of urine, forms a salt which was called native phosphat, or phosphoric salt of urine, or microcosmic salt; it has likewise gone by the name of fusible salt, from it's melting on exposure to heat. According to Spielmann, Schockwitz is the first who described this salt, in a thesis at Halle, in 1699; but Pott attempts to prove, it was discovered before, and quotes Raymond Lully, Isaac Holland, and Van Helmont for this purpose, but he allows, the traces of it's being mentioned in their works are very obscure; it is, however, very extraordinary, that chemists had been so tardy in the examination of it, since it appears spontaneously in the residuum of urine, after evaporation.

When discovered.

Obtained from fresh urine by Boerhaave.

Boerhaave, in describing the process of obtaining the microcosmic salt, has as well as Henckel recommended the urine of healthy people; others from infants, or from those whose only beverage has been beer or wine; and some have even advised it to be taken during the months of March, April, or May. It is very possible that urine is more or less charged with this salt, according to the nature and quantity of the aliments; and it is very evident that the derangement of the animal functions must, to a certain point, influence the nature of the excretions; but in general, as the celebrated Pott has observed, there is no occasion to be so scrupulous, as all urines without distinction afford a sufficient quantity of this salt. There was, however, another difference amongst chemists, and Haupt and Margraaf affirmed against Boerhaave and Henckel, that putrid urine was the best, and this was adopted by Venel, Villermoz, and several others. It may be added, that Margraaf abridged the length of the operation; for after evaporation, instead of one year's repose,

From putrid urine by Margraaf.

in order to ſeparate the cryſtals, as Boerhaave had done, Margraaf demanded only one month, and Schloſſer reduced it to a ſingle night.

The labours of Rouelle, jun. and Prouſt threw new light on this ſubject, and inſtead of ſurmiſes, reduced it to principles. Rouelle ſaw very well, that whether by putrefaction, or the heat of ebullition, a quantity of volatile alcali was diſengaged from the urine, which leaving the acid without a baſis, retarded and diminiſhed the production of cryſtals; hence to avoid that inconvenience, and more completely to ſeparate the common ſalt, he adviſes the urine to be evaporated to the conſiſtence of ſirup, to be filtered when hot through linen, adding at the ſame time a neceſſary quantity of water to prevent cryſtallization. The ſmall quantity of phoſphoric ſalt remaining on the filter with the common ſalt and ſelenite, is eaſily recovered by cold water, and then is added to the filtered liquor. This liquor is then gently evaporated by heat if neceſſary, and when cool volatile alcali is added, and the cryſtals are obtained in abundance, or it is left to evaporate in the open air, which is more difficult. Whatever proceſs is uſed, the ſalt of the firſt cryſtallization is never pure; it is ſoiled by the extractive matter, and contains always a little common ſalt, and *ſal perlatum*, before mentioned.

The proceſs improved by Rouelle.

Since the greater part of the ſalt evaporates by heat, the Duke de Chaulnes has recommended a proceſs which purifies it with the leaſt poſſible loſs; it conſiſts in diſſolving, filtering and cooling the ſolution in well cloſed veſſels, by which means the real phoſphoric ſalt is obtained cryſtallized in very flat rhomboidal quadrilateral priſms, and is now called by chemiſts the phoſphat of ammonia, and above theſe cryſtals is the perlate ſalt, or phoſphat of ſoda, in cubes, or rather long ſquare tablets, and very different from the other.

By de Chaulnes.

Although these two falts were fuppofed to be pure, it is fince found that each is a triple falt, the firft formed of a large proportion of phofphat of ammonia, and a little phofphat of foda, and the fecond in a contrary proportion.

Triple falt of ammonia.

The triple phofphat of ammonia is a falt the cryftals of which, according to Rome de l'Ifle, are in the form of tetraedral rhomboidal prifms, very compreffed, often truncated in their length, and on their angles, from which hexagonal prifms arife refembling Rochelle falt. Longitudinal fegments of thefe prifms are not uncommon. The fide placed on the capfule is larger and more fmooth than the others, fomewhat rhomboidal, and eafily known by two diagonal lines which cut each other in the centre. According to Fourcroy, the tetraedral and octoedral forms are only found when this falt contains a good deal ot muriat and phofphat of foda. The muriat appears more particularly to modify it to the octoedral form, fince on diffolving the firft falt in urine, and expofing it to the fun, in a few days regular octoedral cryftals are obtained.

The favour of this triple falt is at firft cool, then urinous, bitter, and pungent. Expofed to the blowpipe, it fwells, emits an odonr of ammonia, and melts into a deliquefcent vitreous globule.

Diftilled in a retort, a very penetrating and cauftic ammonia is difengaged, the refidue is a very fixed and fufible tranfparent glafs that attacks the retort. Margraaf fays, it prefents the characters of an acid: Rouelle afferts it is deliquefcent: Morveau, on the contrary, believes, that by a ftrong heat it may be reduced to a fixed vitrified ftate.

According to feveral modern chemifts, this glafs, which ftill retains a portion of phofphat of foda, is always opake, or eafily fufceptible of becoming fo; it is only the pure artificial phofphat of ammonia that affords a tranfparent glafs, like the phofphoric acid itfelf.

This ſalt changes very little on expoſure to air. It is very ſoluble in water, requiring only five or ſix parts of cold water; at a heat of 60°, a part of it is decompoſed by this fluid, and a portion of it's acid even is volatilized. It is decompoſed by the cauſtic fixed alkalis and lime, and the ammonia is ſeparated; if limewater be added to it's ſolution, a white precipitate of phoſphat of lime is obtained; the alkaline and earthy carbonat alſo decompoſe it, and the ammonia is ſeparated in the form of a carbonat. It cauſes the fuſion of ſilex, alumine, barytes, magneſia, and lime, but theſe vitreous compoſitions belong to the phoſphoric acid, and the phoſphat of ſoda, ſince the ammonia eſcapes before the fuſion takes place. When treated with charcoal in cloſe veſſels, phoſphorus is obtained. With reſpect to the action of the acids, metals, and their oxides on this ſalt, it depends on the attraction the phoſphoric acid has for the alkaline baſes of the ſalt, theſe metals, and their oxides.

The triple ſalt of ſoda had, as before obſerved, been taken for an acid, by Bergman, called the perlat; by Morveau, the ouretic acid, till Klaproth proved the acid in it to be the phoſphoric.

Triple ſalt of ſoda, or perlate ſalt.

The firſt chemiſts who examined it found, that the great difference between it and the preceding ſalt conſiſted in affording no phoſphorus when mixed with charcoal; but according to Rouelle, who beſt knew it's properties, the cryſtals of the perlate ſalt, or triple ſalt of ſoda, are flat, irregular, long tedraedral priſms, one of the extremities of which is diedral, and compoſed of two rhomboids cut tranſverſely, and the other adheres to the baſis. The four ſides of the ſolid are two pentagons, irregular, alternate, and two lengthened rhomboids.

Expoſed in a crucible, it melts into a white opakeneſs; heated in a retort, it affords a phlegm ſlightly ammoniacal, and the reſidue is a glaſs much more opake than that

from the triple phofphat of ammonia. This falt, when expofed to the air, effervefces, and falls into a powder. It is foluble in diftilled water, which changes the firup of violets green, and it may be cryftallized on evaporation. It is decompofed by nitrat of lime; the precipitate is phofphat of lime, and the water affords nitrat of foda. It is alfo decompofed by the nitrat of mercury. Alfo by lime, for if limewater be poured into a folution of this falt, a precipitate is formed, and the foda remains pure and cauftic in folution. Likewife by the acids. It is not decompofed by charcoal like the phofphat of ammonia, and it is equally curious that the phofphoric acid, when added in excefs to the phofphat of foda, leaves it the property of changing the firup of violets green. Laftly, this phofphat of foda always contains a little phofphat of ammonia, and this laft always plays it's part in every combination it is made to undergo.

Hence it appears, that the falt obtained by the cooling and repofe of urine, when evaporated, and which from it's melting by heat was originally called fufible falt, the effential falt of urine, or microcofmic falt, is principally compofed of thefe two triple falts, which only differ from each other in the proportions of the two alkalis; but as it would be trefpaffing too much on the defign of this work to enter into a more minute detail of them, it will be neceffary to conclude with a few obfervations of Fourcroy. He found, after various trials, that it was impoffible completely to feparate them, fo intimate is their combination. He found, that after keeping a few pounds of this falt of the firft cryftallization, for about fix years, in a well covered glafs bottle, a very fenfible mufk or amber odour had fucceeded it's peculiar fœtid odour; that this fufible falt, which effloresces in the air, always greens violet paper; and this effect is produced whether the cryftals be obtained at the beginning or end of the

Remarks of Fourcroy.

operation, *i. e.* whether they be phoſphat of ſoda and of ammonia, or phoſphat of ſoda almoſt pure. This is the more ſingular, ſince it is proved that urine on evaporation loſes ſome of it's ammonia, without loſing the phoſphoric acid in proportion, and in conſequence becomes acid; yet the ſalt obtained greens inſtead of reddens the blue of the violet. Another not leſs remarkable circumſtance is, that this ſalt expoſed a long time to the air entirely paſſes to the ſtate of phoſphat of ſoda, which always greens violet paper. The phoſphat of ammonia, therefore, appears to be completely volatilized by the ſimple heat of the atmoſphere, as Rouelle and Chaulnes had already obſerved. The different triple ſalts obtained from it all afford ammonia by lime. To find the exact proportions in this ſalt, Fourcroy diſſolved it in cold water, and precipitated it by limewater; the precipitate collected, dried, and weighed, then ſaturated with muriatic acid, and evaporated, and the weights of the muriats of ſoda and ammonia obtained, gave the proportions of the phoſphats of ſoda and ammonia. He found that one hundred grains of this fuſible ſalt of urine afforded,

	grains.
Of ammonia	19
ſoda	24
phoſphoric acid	32
water	25
	100

Beſides the combinations of ammonia and ſoda with phoſphoric acid in urine, it likewiſe contains the muriat of ſoda, the phoſphat of lime, and the lithic acid; for which two laſt, *vide* Bones and Acids.

According to Leibnitz, phoſphorus was firſt procured from urine by Brandt, about the year 1667, as he was endeavouring to obtain a liquor from this fluid, in order

Phoſphorus obtained from urine.

to convert ſilver into gold. He made this diſcovery a little time after Baudoin had found the phoſphoric property of the Bolognian ſtone. Brandt communicated this diſcovery to Kraft and Kunckel, who aſſociated together in order to find out the ſecret; but the one having acquired it for himſelf alone, Kunckel, who knew only that it was procured from urine, made the attempt and ſucceeded. This ſucceſs not being the effect of chance, chemiſts have thought proper to give him the honour of the diſcovery of phoſphorus, by naming it *Kunckel's phoſphorus.* Kraft either told Boyle the ſecret, as Stahl affirms, or Morveau thinks, gave him a ſpecimen of the production. Kunckel, and a German chemiſt, Hatwitz, who worked in the laboratory of this Engliſh philoſopher, were a long time the only perſons who prepared phoſphorus in quantity, and from it's having been ſold by the laſt to moſt of the philoſophers of Europe, it received the name

In England. of *Engliſh phoſphorus.* Although from 1680, to the beginning of the preſent century, a great number of receipts for making phoſphorus had appeared, and amongſt others, thoſe of Boyle, Kraft, Brandt, Homberg, Teichmeyer, Hoffmann, Albinus, and even Kunckel, who had publiſhed his own proceſs in a work entitled, *The Chemical Laboratory*, yet the proceſs was not generally

France. known; and the firſt time it was repeated in France, was by a foreigner, in 1737, who performed it in the Royal Garden, in the preſence of four chemiſts of the academy,

Proceſs by Hellot. Hellot, Dufay, Geoffroy, and Duhamel, and the proceſs ſucceeded. Hellot afterward deſcribed it in a memoir for the year 1737 of that ſociety. This operation conſiſts in evaporating five or ſix barrels of urine until it becomes grumous, black, hard, and ſhining; the reſiduum calcined in an iron pot, the bottom of which is made red hot, until there is no more ſmoke, and there ariſes the odour of peach flowers. It is then lixiviated with twice the quantity of warm water, and then exſic-

cated after decantation. Three pounds of this are to be mixed with one and half of ſand, and four or five ounces of beech charcoal, then moiſtened with half a pound of water, and put into a Heſſian retort. It is eſſayed firſt by a red heat in a crucible; for when a violet coloured flame and a garlic ſmell ariſe, it will produce phoſphorus. The retort is then placed in a furnace, and a large receiver is fitted to it, one third part of which is filled with water. This receiver muſt have a hole pierced through it, which Hellot looks upon as very neceſſary, in order to ſucceed. Three or four days after this preparation, a gentle heat is applied to dry the furnace and lutes; it is then increaſed to the utmoſt violence, and kept up for fifteen or twenty hours. The phoſphorus only comes over fourteen hours after the beginning of the operation, which laſts for twenty-four hours; a large quantity of carbonat of ammonia ariſes, which is in part diſſolved by the water. The volatile or aeriform phoſphorus ariſes firſt in luminous vapours, then the real part runs like an oil or melted wax. When no more comes over, it is left to cool for two days, the lute is taken off, and water is added to that in the receiver to detach the phoſphorus adhering to it's ſides. It is then melted in boiling water, cut into ſmall pieces, which are introduced into glaſs tunnels, (matraſs necks) and plunged into boiling water. The phoſphorus melts, purifies, and becomes tranſparent from the ſeparation of a blackiſh matter which riſes above it. It is then put into cold water, in which it becomes hard, and it is extracted from the tunnels by puſhing it with a ſtick. Such is the proceſs deſcribed by Hellot, (*vide* Phoſphoric Acid). According to Macquer, however, the firſt time that Rouelle tried this method, it did not ſucceed from the failure of the retort, but he afterward repeated the operation in his chemical lectures,

and from it's length and labour, he was the only chemist who repeated it.

Improved by Margraaf. In 1743, Margraaf published a method of extracting it more easily. The urine is first reduced to the consistence of honey, and nearly three barrels are necessary for one ounce of phosphorus; during the evaporation a few ounces of tallow are cast into the vessel to stop the rising up occasioned by the heat. Ten pounds of this extract are then mixed with some muriat of lead (plomb corné) the residuum of the distillation of 4lbs. of minium and 2lbs. of ammoniacal muriat, and half a pound of pulverized charcoal is added. This is then to be stirred in an iron pot until it is reduced to a black powder, then distilled in a retort by a gradual heat to extract the carbonat of ammonia, the fetid oil and the muriat of ammonia, taking care not to push the heat until the retort is somewhat red, and the black and fusible residue is the matter from which the phosphorus is extracted. It is essayed by casting a little of it upon red hot coals; if there arise a blue flame, and a garlic small, it is well prepared. A Hessian retort is then filled with it even to $\frac{3}{4}$, is placed in a furnace with a receiver adapted, having a hole in it, and half filled with water, well luted, and here it is left to dry a day or two, and then the distillation is begun by a gradual heat. This lasts from six to nine hours, according to the quantity of matter. The phosphorus is then rectified by a very gentle distillation, in a glass retort, with a receiver half filled with water. This process was practised with success by the academicians of Dijon, in their first course of lectures, in 1776, but the noisome odour which arose on mixing the muriat of lead with the extract of urine would have prevented it's being continued, and although almost all the chemists were obliged to make use of this method, the discovery of procuring it from other materials rendered it unnecessary.

It appears that the procefs of Margraaf only differs from that of Hellot by the addition of muriat of lead, and by the operation being performed at twice, but the moft curious part is, that this Pruffian chemift has determined what the fubftance contained in urine is, that ferves to form the phofphorus. On diftilling a mixture of *fufible falt* and charcoal, he obtained a beautiful phofphorus, and he obferved that the urine from which this falt was extracted afforded fcarcely any of this combuftible fubftance; hence it muft be a conftituent part of this falt that contributes to the formation of phofphorus, and this fubftance is eafily obtained by diftilling two parts of glafs obtained from this falt decompofed in a crucible or retort, with one part of powdered charcoal. This operation requires lefs time and heat than thofe already defcribed, fince according to Prouft, the phofphorus runs in a quarter of an hour; but although this procefs is the beft to extract phofphorus from urine, there are feveral obfervations to be made. 1. Very little phofphorus is obtained; for the vitreous refidue of the decompofition of ammoniacal phofphat by heat is not pure phofphoric acid, but combined with foda, which is not decompofable by charcoal; hence one ounce only affords one drachm of phofphorus at moft. 2. When the fufible falt is prepared by evaporation, and cooling in large quantity, a great deal of phofphat of foda is mixed with it, which affords no phofphorus. From thefe two remarks, therefore, it appears why fo little phofphorus is obtained on diftilling fufible falt with charcoal; and perhaps the fame falt entire, diftilled with coal and muriat of lead, may afford more, fince this laft appears to have the property of decompofing the phofphat of foda; and we are informed by Morveau, that Black made the experiment; for being affured that the falt formed of phofphoric acid and foda was not decompofed by charcoal affifted by heat,

The difference between them.

he attempted this decompoſition by the muriat of lead, and he ſucceeded in obtaining phoſphorus, which proves the advantage of Margraaf's method. The diſagreeable ſtench ariſing from the evaporation of urine, and the labour required in the proceſs for procuring this combuſtible ſubſtance, were however great reaſons for diſcontinuing the practice, and the method of extracting it from bones, as diſcovered by Gahn and Scheele, which is eaſy and pleaſant, has entirely put an end to the procuring of it from this fluid.

Fourcroy and Vauquelin diſcover a new ſubſtance, and call it urée.

Having thus given ſome account of the experiments that have been made on urine, and of the matters which have been ſuppoſed to exiſt in it, or are conſidered as forming part of it's conſtituent principles, it remains to detail the analyſis and obſervations of Fourcroy and Vauquelin, who have found a peculiar matter in this fluid to which they give the name of *urée*. It appears this matter forms the greater portion of the compoſition of this fluid; to it is owing it's odour, ſavour, and the changes it undergoes; and it is by reaſon of this, that urine differs from all other animal fluids, ſince it characterizes it's nature, and without it this fluid would no longer be what it really is.

Which had been ſlightly obſerved before.

With reſpect to the diſcovery of this peculiar ſubſtance, Rouelle the younger is the firſt that has given any preciſe idea of it. Indeed the generality of thoſe who have examined this fluid chemically ſeem to have had ſome little notion of it, but they did not take ſufficient notice ſo as to form any knowledge of it's properties. It is undoubtedly this matter, the tinging quality of which, and property of giving different ſhades of colour to this excrementitious liquid according to it's quantity,

By Bellini.

Bellini had obſerved; but being entirely taken up with the coloration of urine, he never thought of examining the nature of the colouring matter. Boerhaave,

Boerhaave.

ſpeaking of a ſort of ſapa, or extract of urine, compares it to a kind of honey, and deſcribes it as bitter, ſharp, and not alkaline. Margraaf, in deſcribing the ſalt of urine that affords phoſphorus on diſtillation, ſays, that a fat matter, or *fæces pingues*, is depoſited with it, which affords a ſpirit of ſalt and ſome oil by diſtillation. Pott, Schloſſer, Haupt, and others, likewiſe perceived it; and it is impoſſible for it to have entirely eſcaped the notice of chemiſts, who have examined urines by different means, although they have ſaid nothing in particular of it.

Margraaf.

Pott.

Rouelle is the firſt who has mentioned it more explicitly; and having diſcovered a few of it's characters, deſcribed it by a particular name, twenty-five years ago, evidently with an intention of diſtinguiſhing it as a diſtinct ſubſtance. This is the *ſaponaceous matter* already mentioned. He informs us, it is of a deep brown colour, has a diſagreeable odour, is of an oily conſiſtence, is cryſtallizable, but not ſuſceptible of exſiccation, is acted upon by heat like a mucous body, extremely deliqueſcent, containing the muriatic acid in a ſtate of combination; affording by analyſis more than half it's weight of volatile alkali, a little oil, and ſome ſal ammoniac, but that the reſiduum contains nothing alkaline. From this account, it appears, that Rouelle had well characterized a peculiar ſubſtance, which he was deſirous particularly to diſtinguiſh from extracts, and which is the *ureè* of Fourcroy and Vauquelin. Rouelle regarded this ſoapy matter of urine as the *nutritious matter of vegetables, changed in it's nature by digeſtion and circulation, and by new combinations it had formed on paſſing into the animal economy, with which it became aſſimilated*; and he obſerved, that with the extractive matter, it was the moſt changeable of any of the component parts of the urine.

Rouelle, the firſt who has any ways characterized it.

Nearly forgotten fince the time of Rouelle, it appears to have efcaped the attention of chemifts, until Scheele, in his memoir on the vefical calculus, mentions it without defcribing it, by the name of *oily extractive* matter. Cruickfhank has, however, given an account of fome of it's properties, and has diftinguifhed it from all others which have been as yet related by two of it's moft characteriftic and ftriking qualities; for, in the work of Rollo, on diabetes, this chemift informs us, that the animal extractive matter of urine affords, on diftillation, at firft water impregnated with carbonat of ammonia, the fame falt in a concrete ftate, then a fetid empyreumatic oil, afterward a little phofphorus, and an animal coal is left of difficult incineration. Treated with twice or thrice it's weight of nitrous acid, it affords half it's weight of flat, rhomboidal, and fhining fcales, refembling the acid of borax. By expofure to a gentle heat, the fcales evaporate in a white fmoke; to a ftrong heat, they burn with a red flame, and a kind of detonation refembling that from nitrat of ammonia.

Scheele.

Cruickfhank.

Extraction of uree.

The method of feparating this peculiar urinary matter is by evaporation. The urine of an adult perfon, voided feven or eight hours after a meal, is to be evaporated in a glafs veffel by a gentle heat, until it has acquired the confiftence of a thick firup. It is then of a deep brown, has a fetid odour, and it's nature is evidently ammoniacal. During it's cooling, the whole mafs takes the form of granular cryftals, which are a mixture of all the falts with the ureè. To obtain this, four times it's weight of alcohol is to be poured upon it at feveral times, and expofed to a flight heat. The greater part is now feen to diffolve, and give an obfcure brown colour to the liquor, and there remains a faline matter nearly white, which Rouelle advifed to obtain in this manner, and from

it's ſolubility in alcohol, he named that which this menſtruum took up, *ſaponaceous matter.*

This brown alcoholic ſolution is then to be poured into a glaſs retort, expoſed to a ſand heat, and a fetid alcohol is obtained, charged with carbonat of ammonia, which efferveſces with acids, and which, on their addition, becomes of a roſe colour, from dragging with it a certain proportion of ureè. This diſtillation is continued until the ebullition is pretty ſtrong, and until the liquor acquires a ſirupy conſiſtence. The alcohol being diſſipated, the whole matter on cooling cryſtallizes in the form of interſected ſubquadrangular plates, the edges of which appear to be cut; their colour is of a ſhining yellowiſh white, and even browniſh in many points. This cryſtalline maſs exhales the odour of fetid urine, with a garlick ſmell, it's taſte is ſtrong, pungent, and reſembles that from ammoniacal ſalts; it deliqueſces, and is converted by degrees into a thick brown liquid. It's odour in particular is extremely characteriſtic; it's ſtench is inſupportable, reſembling that of arſenical ſulfures. Beſides the diſguſt it cauſes, theſe chemiſts ſuſpect it's capability of producing diſeaſe, for on being employed ſeveral hours upon it, they contracted a headach, and were indiſpoſed.

It's properties.

On detaching ureè from the veſſels in it's cryſtalline form, it reſembles a granular paſte; is difficult to cut; viſcous, tenacious; internally, very ſolid; externally, ſofter, like a thick honey, to which Rouelle compared it, as Boerhaave already had before. It diſſolves ſo rapidly in water, that it is only neceſſary to pour a ſmall quantity into the veſſel that contains it, immediately to detach it, and on the ſlighteſt agitation, it becomes a thick brown liquid. During this ſolution, a very ſenſible coldneſs is produced.

Ureè is ſomewhat leſs ſoluble in alcohol than in water; it's alcoholic ſolution affords cryſtals much more eaſily on cooling, than that procured by water.

Forms a curious ſalt with nitric acid.

On mixing it's aqueous ſolution, ſomewhat concentrated, with nitric acid, cryſtalline plates are inſtantly depoſited, which are white, ſhining, and pearly. Urine, when exſiccated, preſents the ſame phenomenon: it ſeems that the ureè forms with the acid a ſort of ſalt that is little ſoluble, and very cryſtallizable. This property is one of the moſt ſingular and characteriſtic of this matter. The other acids do not produce the ſame effect. The muriatic precipitates it from it's alcoholic ſolution in the form of white flocks.

It's aqueous ſolution aſſumes different colours.

It's ſolution in water is of a brown colour when this fluid is in ſmall quantity, but it is made to paſs through all the ſhades of orange, yellow, and lemon colours, by the quantity of menſtruum, ſo as to imitate every ſpecies of urine; it's concentrated ſolution precipitates the nitrat of lead of a brown yellow, which may be rediſſolved after ſome time in much water. On evaporating the liquor from which the precipitate is formed, ſmall ſhining ſilverlike cryſtals are obtained. On treating the precipitate of lead by the blowpipe, it ſwells, blackens, flies off in a white ſmoke, and leaves behind it a metallic button of lead. This ſolution precipitates the nitrats of mercury and of ſilver, white; mixed with ſuperoxygenated muriat of mercury, which it does not precipitate, it gives to the oxyd ſeparated from it by an alkali a gray flax-colour. It appears to be the ureè which gives to urine the property of forming, with the nitric ſolution of mercury, a roſe-coloured precipitate, already obſerved and deſcribed by Lemery at the end of the laſt century.

Precipitates the nitrat of lead.

And nitrats of mercury and ſilver.

Action of galls upon it.

Gall nuts give the ſolution of ureè a yellowiſh fawn colour, without precipitating it.

And of tan.

Tan ſomewhat changes it's colour, but does not cauſe

a precipitation, ſo that it may be of uſe to ſeparate it in ſome manner, or rather to ſeparate from it the animal albuminous matter which accompanies it in urine.

Uree when expoſed at firſt to a gentle diſtilling heat in a glaſs retort, and the fire afterward raiſed ſo as to redden the veſſel, is ſoon melted. Almoſt on the firſt acceſs of heat, a white vapour ariſes, which becomes condenſed and cryſtallized near the mouth of the retort, having every appearance of benzoic acid. Another concrete body ſoon ſucceeds this firſt ſublimate, eaſily known to be the carbonat of ammonia. This new product appears without interruption, even to the end of the operation. There is no oil, nor condenſed water, the ſublimed ſalt being only a little brown. The air extricated is at firſt impregnated with a diſagreeable garlick odour, reſembling that from putrid fiſh, and it carries over with it ſome carbonat of ammonia, which renders the ſpring water of the tub, in which the pneumato-chemical apparatus is contained, turbid. When the fire begins to be very intenſe, the odour of the product, always ammoniacal and an elaſtic fluid, becomes a ſtench really inſupportable, ſtill preſerving the ſame character of putrid fiſh and garlick. The matter at the bottom of the retort appears in a dry form, of a blackiſh colour, and covered with a white raiſed cruſt; this cruſt ſublimes into a heavy vapour, and attaches itſelf to the loweſt part of the retort above it's bottom. It is the muriat of ammonia. After more than two hours expoſure, the coaly reſiduum left behind afford, by lixiviation, a liquor of the odour of pruſſic acid, which precipitated, by means of an alkali, ſolutions of iron, of a blue colour. It ſtill contained ſome muriat of ſoda, and a little muriat of ammonia. On calcining the coal, there aroſe an ammoniacal odour, mixed with that of the pruſſic acid, or bitter almonds during the whole time. There remained leſs

Diſtillation of uree.

than $\frac{1}{100}$ part of the diſtilled ureè in weight, of a white matter, ſharp, ſoluble, changing violets to a green, effervefcing with acids, and having great analogy to carbonat of ſoda.

Products and conſequences of this proceſs.

From this proceſs it appears, that ureè contains the benzoic acid, muriat of ammonia, and a little muriat of ſoda; that it is very decompoſable by fire; that the moſt abundant product of this decompoſition is ammonia; that neither water nor oil (at leaſt in ſufficient quantity to be eſtimated) is formed; that there is a ſufficient portion of carbonic acid produced to ſaturate the ammonia, and a little pruſſic acid; that the carbonated hydrogenous gas, the carbonic acid and azot gaſes, diſengaged, are very difficult to determine; that the carbonat of ammonia, impregnated with a little animal oil, horribly fetid, conſtantly ſaturated the air of the apparatus, which expanded even to it's extreme part, and that the principles, azot, hydrogen, carbon, and oxygen, ſo diſpoſed to take a gaſeous form, conſtitute the ureè in ſuch proportions, as to be converted by the action of heat into ammonia, pruſſic and carbonic acids, inſtead of forming water, oil, and nitric acid, which they form in other circumſtances hereafter to be mentioned. Likewiſe the great quantity of ammonia in the products announces that azot occupies the firſt place, by it's proportion amongſt the conſtituent parts of ureè. This reſult, very different, as is evident, from what former chemiſts, and particularly Rouelle jun., Scheele, and Cruickſhank had related of this pretended ſaponaceous, animal extractive, or oily extractive ſubſtance, engaged Fourcroy and Vauquelin to obtain the proportions of the products during the diſtillation, in as exact a manner as poſſible; and they found, that 288 parts of ureè afforded, with 0,03 of loſs, 200 parts of carbonat of ammonia, 10 of carbonated hydrogenous gas, 7 of coaly reſiduum, 68 of

Nature of the products.

muriat of ammonia, of benzoic acid, and of muriat of ſoda, with ſome traces of oil, and pruſſic acid, that could not be eſtimated; hence it appears, that this proceſs was of great uſe in determining the compoſition of this matter.

Two parts of cryſtalline ureè with one of diſtilled water, being mixed at a temperature of 10°, melted, forming thick and brown ſtriæ; eight parts more of water being added, the ſolution, which was very clear and coloured, was poured into a large glaſs retort by means of a funnel, when a very evident white vapour aroſe from it, originating from the diſengagement of a little ammonia uniting to the water, and the carbonic acid of the atmoſphere. This being diſtilled on a ſand bath, to a ſlight ebullition, and until the ſolution had acquired the conſiſtence of ſirup, it was of a deeper colour, and leſs cryſtallized than at firſt, and the water which came over was a very pure and tranſparent ſolution of ſaturated carbonat of ammonia. Uree diſtilled with water.

The ſame quantity of diſtilled water being put upon the cooled matter, it was diſtilled a ſecond and a third time, with the ſame effect, except that the colour of the ſolution of carbonat of ammonia was rather brown from the ſecond diſtillation, and deeper coloured or rather oily, with a depoſit of a certain quantity of carbon from the third.

During theſe three ſucceſſive operations, in which more than half the weight of ureè was afforded of carbonat of ammonia (0,546), this matter was not exhauſted, from the formation of it; for diſſolved in a fourth quantity of water, it preſented the characters of acetous acid, and although it had depoſited a little carbonaceous powder, it loſt this acid ſtate on four or five days expoſure to about 20° of Reaumur, and again exhaled ammoniacal water by evaporation; beſides it depoſited octoedral cryſ-

tals of muriat of soda, and gave, after being thickened, a shining pearl-like precipitate by the nitric acid, a proof that in spite of the great quantity of ammonia formed, still a portion of ureè remained undecomposed.

It's easy decomposition.

Hence it may be concluded, that the water dispersing the molecules of dissolved ureè, and not permitting them to undergo a temperature higher than that of it's ebullition, is sufficient to decompose it; that this temperature which does not disorganize animal substances either completely or easily, but only is capable of changing their consistence, savour, and odour, has the power of destroying the intimate attraction which keeps the principles of ureè united in a composition at least quaternary; that this phenomenon, hitherto unknown amongst organic substances, announces, that this is of an order of composition still more complicated, if possible, and it's equilibrium more slight and easy to destroy.

Remarks upon it.

It is not only in the formation of ammonia that the sudden decomposition of ureè appears, at a temperature and by a process, which before would have been looked upon as impossible; perhaps the formation of carbonic acid in the midst of an aqueous liquid, and at the heat of ebullition, is still more remarkable. It is to be observed, that there is only a quantity of it formed sufficient to saturate the ammonia, for there is neither effervescence nor a disengagement of gas in this experiment, and the proportion of carbon separated during this decomposition of ureè, exceeds the quantity of oxygen which might produce combustion, since a portion of this principle is deposited alone. With respect to the formation of acetous acid, at a heat nearly that of the baln. mar. and in so diluted a solution, it appears, that in this the decomposition of ureè, by the long action of boiling water, approaches that which happens during it's fermentation, and which is the case with urine during it's spontaneous decomposi-

tion, and in effect, urine only differs from this artificial solution of ureè, in having this matter combined in part with saline substances that retard the decomposition, when not excited by some fermentative or putrescent principle, which is the case when urine contains a gelatinous or albuminous matter, in a somewhat larger proportion than common.

One part of ureè dissolved in 64 parts of water, was left in an ill-corked bottle, filled to $\frac{5}{6}$ of it's volume, for about seven weeks, the temperature being above 165°, when a fermentation took place in this fluid which was of a brownish-red colour. Bubbles of air continually arose, it became covered with a light foam; the void part of the bottle contained a fluid that extinguished a candle; it exhaled a lively, sharp odour, that was acidulous, urinary, and disagreeable. Some compared it to that arising from marshes, others perceived the odour of vinegar. In distinguishing this last, Fourcroy likewise observed something of ambergris, the odour of which, he had observed before, in a brown, fusible, impure salt, kept for several years in his laboratory. This liquor was left four weeks longer, and as in three months every sign of fermentation had disappeared, it was submitted to distillation, after the addition of twice it's primitive weight of concentrated sulphuric acid. The odorous and evidently acetous product obtained, likewise contained the benzoic acid; both acids were procured by combining them with potash. The residuum contained sulphat of ammonia and carbon. It's spontaneous decomposition.

During this spontaneous decomposition of ureè, some deep-coloured urine was exposed to the same, and it was observed, that this last underwent it more rapidly; and as some species of pale, or slightly coloured urines, in which, however, tan caused a very evident precipitation, were more rapidly decomposed, and, as it was supposed, Compared with urine.

that this ſudden change might depend on an animal matter that ſerved as a ferment, $\frac{1}{8}$ in weight of albumen was added to a ſolution of ureè compoſed of 60 times it's weight of water. This mixture was found to ferment much ſooner than the pure ſolution of ureè, or the urine. The ſigns of fermentation were much more evident, the liquor became turbid and full of flocks; a more abundant ſcum aroſe to the top, which was more thick and tenacious; the odour was more fetid; more air bubbles were diſengaged, and although the acetous acid was produced as in the other two, the quantity of ammonia formed at the ſame time was more conſiderable, ſo that the liquor was alkaline, and the decompoſition in general much more advanced.

Is both acid and putrid.

This ſpontaneous decompoſition of ureè by a real fermentation, is both acid and putrid at the ſame time. It differs ſingularly from that by the fire, by producing more acetous acid and leſs carbonic acid and ammonia than by heat, which ariſes from the different attractions. During the ſpontaneous decompoſition, it appears, that the principles are not ſo ready to form binary unions, their attraction being more tranquil; hence the acetous compoſition which prevails over the other effects that accompany the production of this acid. The portion of carbonic acid is diſengaged as it forms, and cannot remain diſſolved in the ſame liquor as the acetous.

Action of acids on ureè.

The treatment of ureè by acids, which act upon it in a manner very different from what they do on other animal ſubſtances, and the compariſons to that by heat, are the means which theſe chemiſts employed to obtain a knowledge of it's conſtituent principles.

The ſulphuric acid.

An aqueous ſolution of pure ureè mixed with $\frac{1}{4}$ of it's weight of diluted ſulphuric acid, produced no efferveſcence. On a ſlight ebullition in a retort, it became covered with an oily and black matter, which fixed on

cooling. The action of fire on this matter produced no oil, as before observed, but a disengagement of carbonated hydrogenous gas, and a precipitate of carbon. The product in the receiver, after the *oleaginous* action of the sulphuric acid, was a yellowish coloured liquor, in which dark brown particles, evidently carbonaceous, were observed to swim; it's odour resembled that of the empyreumatic acetous acid, arising from the decomposition of an alkaline acetite by fire; it's savour was sharp and hot, like that of distilled oil. It reddened the tincture of turnsole, without precipitating the soluble salts of barytes; hence it contained no sulphuric acid. Saturated with lime, it gave two salts, viz. acetite and benzoat of lime. Hence the benzoic acid accompanies ureè in it's crystalline precipitation.

During the first action of the sulphuric acid on ureè, a part of this matter had undergone another species of decomposition, for the red residual liquor of this distillation gave sulphat of ammonia in sufficient quantity. This salt, however, formed in part by the union of the sulphuric acid to the ammonia, united to muriatic acid, since the ammoniacal muriat evidently exists in ureè, as is proved by the disengagement of muriatic acid effected by concentrated sulphuric acid, and that of ammonia by potash. Yet a portion of ureè itself is converted into ammonia during the double action of heat and sulphuric acid.

On repeating these distillations, the same effects take place, but after the first, there remains much ureè undecomposed, and which is precipitated again in crystals, on the addition of nitric acid a little concentrated. Hence the sulphuric acid, when weak and warm, converts, by degrees, ureè into acetous acid and ammonia, separates the benzoic acid it contains, and takes the ammonia from the muriatic acid, which it conceals in union; at the

fame time it converts a portion into the ftate of oil, and feparates a part of the carbon, which colours, and even renders the folution turbid, from which it may be concluded, that the fulphuric acid acts upon ureè in the fame manner nearly as the flow or putrefactive decompofition.

It's action fimilar to putrefaction.

The nitric acid.

The manner in which the nitric acid acts upon ureè is the moft fingular of all. It's power on organic fubftances is well known, and the phenomenon it produces with ureè has been already indicated by Cruickfhank in the remarkable precipitation it produces, which is one of the characters that particularly diftinguifhes ureè from all other fubftances.

This precipitate, which is lamellated, radiated, white, fhining like fatin, foon becoming of flax gray, brown, and even black, in fufficient quantity to fill the veffel, and convert all the urinary liquid into a folid and cryftalline mafs, in a few feconds, and even at the moment almoft as the nitric acid, fomewhat ftrong, is poured on urine, evaporated to the confiftence of firup, or on a folution of ureè fufficiently concentrated, to be of that confiftence, is a phenomenon unknown to chemiftry in treating animal fubftances with the nitric acid. To determine the nature of the precipitate, it was cautioufly heated, it became foft, and melted like oil; a brifk effervefcence took place, and part was converted into nitrat of ammonia. Hence this cryftalline depofit is a compofition of ureè and nitric acid; it is not pure ureè feparated from it's folution by the acid, but the product of an intimate union, which does not take place between any other acid and ureè, and hence ought to be looked upon as peculiar to the nitric acid.

Concentrated.

In order to determine the action of very concentrated, and very diluted nitric acid upon ureè, affifted by heat, as was the cafe with the fulphuric acid, the moft concentrated nitric acid, particularly that more or lefs impreg-

nated with nitrous gas, being poured on ſolid ureè, excited a conſiderable effervefcence and much heat; the matter roſe up, ſwelled into a foam, melted into a deep red liquor, part rejected or thrown out of the veſſel by the numerous bubbles of nitrous azot and carbonic acid gaſes, which are diſengaged with impetuoſity. It appeared as if the mixture, agitated and boiling, was going to inflame, and yet this violent action conſtantly ceaſed, the maſs ſunk, and there only remained a portion of white yellowiſh concrete matter, with a few drops of a red liquor. If this reſiduum be expoſed to a lively heat, it detonates, and inflames in the ſame way as ammoniacal nitrat. In this proceſs, therefore, the ureè is decompoſed and converted into carbonic acid and ammonia; but there is nothing of an oily nature; the decompoſition, however, being too rapid to determine the products, it was better obſerved during the ſlow action of the diluted nitric acid.

Upon ureè cryſtallized by evaporation of the alcohol, and deliqueſced ſo as no longer to be of a thick ſirupy conſiſtence, was poured an equal part of nitric acid, reddened by nitrous gas, and at 1460 of concentration, united with it's weight of diſtilled water, in a tubulated retort; but the effervefcence being ſtill too great, another equal portion of water was added. After this, the homogeneous, brown, and liquid mixture, only produced a ſlight and gradual effervefcence, but conſtant and without interruption. The retort was placed on a ſand bath which was gently heated, and kept at the ſame degree during the proceſs, which laſted nearly two days. The moſt remarkable phenomenon is the diſengagement of gas, which is conſtant and regular, the quantity of which amounted nearly to 24 cubic decimeters; more than $\frac{5}{6}$ or 25 grains belonged to the ureè, as will appear, which make nearly $\frac{1}{3}$ of the matter employed. Diluted.

During the firft day, more than 18 cubic decimeters of gas came over; and even to the quantity of 10 or 12 cubic decimeters it was compofed of azot and carbonic acid gafes, which laft was known by means of a lye of pure potafh. As to the fix cubic decimeters of this firft part of the diftillation, the azot gas was replaced by atmofpheric air.

The fecond day, nearly fix cubic decimeters of gas were obtained, mixed with the oxyd or nitrous gas, and carbonic acid; the liquor was never carried to ebullition, and the uniform effervefcence was conftantly maintained by very fmall bubbles, equally difengaged from the whole furface of the liquor.

Towards the time when the production of azot gas ceafed, the colour of the liquor, until then red, becoming weaker, paffed to a yellow colour, and there was no precipitation, no black flock, nothing of a carbonaceous nature to be feen,

At the fame period, the portion of gas infoluble in the lye had a ftrong odour, and produced tears from it's irritation. It communicated this odour to water, and refembled the febacic, or rather what Berthollet calls the oxygenated pruffic acid. This gas, which appeared by the eudiometer to be a mixture analogous to atmofpheric air, holding a little pruffic acid in folution, only arofe after the ceffation of the azot gas, and at the moment the nitrous gas became evident.

At the end of the fecond day, the matter becoming thick, and affording, with difficulty, a vapour to be condenfed in the receiver, inflamed with a violent explofion, and a fat carbonaceous matter remained, which gave the water, with which it was lixiviated, a very fenfible odour of pruffic acid, and of ammonia, with the property of precipitating red folutions of iron in the form of Pruffian

blue. After this action of the water, the coal formed nearly the 240th, or 0.0044, of the weight of the ureè.

In the receiver there was a greenifh yellow liquor, very acid, upon which fome oily particles were feen, whilft the penetrating odour announced it's nature to be that of the gas.

In fpite of every care, thefe chemifts experienced a pretty confiderable lofs during this experiment of the decompofition of ureè by fire and the nitric acid, which appeared from the ftrong odour it diffufed in the laboratory; but at the fame time, the action of the nitric acid on this fubftance alone fhows it to be different from every other animal fubftance, it's mode of decompofition being limited to the abundant extrication of azot and carbonic acid, and to the formation of ammonia and pruffic acid. As to the atmofpheric air obtained toward the end, it arifes from the decompofition of the nitrous gas, and a portion of oxygen gas fet at liberty. Every thing, therefore, during the action of this acid, announces the ureè to be a fubftance furcharged with azot, befides containing hydrogen and carbon fingularly difpofed to be converted into ammonia, as well as the eafy feparation of a great quantity of azot become free and capable of taking the elaftic ftate. It's conftituent principles are likewife eafily detached in a gafeous form, and it appears to have a decided tendency to be fooner and more perfectly decompofed by ftrong reagents than other fubftances.

The action of the nitric acid, therefore, as well as that of caloric, proves ureè to be a fubftance containing a great quantity of azot, and the compofition of which particularly conceals the union of this fuperabundant principle with hydrogen, carbon, and even oxygen. As to the fmall quantity of benzoic acid, and muriat of am-

monia, which appears conftantly to accompany ureè, they are loft during the procefs.

The oxygenated muriatic acid.

The muriatic acid has no fenfible effect on ureè; but in an oxygenated ftate, partially decompofes it in a fingular manner. Some ureè of the confiftence of firup, being diluted with four parts of diftilled water, and put into one of Woulfe's bottles, to which a fecond was adapted full of water, and terminated by a tube plunged under a glafs veffel, fome oxygenated muriatic acid gas was made to pafs through it at the moment of it's production. The liquor was of a deep brown, but tranfparent. The gas paffing in great abundance in blebs, was fpeedily diffolved; fmall brown flocks, clearer than the liquor, were feparated, which foon became yellow, and adhered to the fides of the glafs like a concrete oil. The liquor, which always ftopped and diffolved the gas, foon became of a white beer colour, the flocks yellow, and thofe that were precipitated were found after the procefs to keep up an effervefcence for five days, although the gas had only been communicated a few hours until the faturated liquor refufed to diffolve it. Six cubic inches of gas were, however, only collected, a third of which was carbonic acid, and the two others azot gas; the oxygenated muriatic acid difengages much lefs gas from ureè than the nitric acid, and fixes rather than volatilizes it's principles; for it appears, that although there was an excefs of this reagent in the folution, a great part remained untouched; and as the liquor at the fame time contained a fufficient quantity of free muriatic acid, it was found that one portion of the oxygenated muriatic acid gas was firft diffolved in the liquor, and precipitated a part of the ureè; that foon afterward a fecond portion of the fame gas reacted upon the flocks of precipitated ureè, difcoloured them, difengaged the azot, confumed

a part of the carbon; in ſhort, decompoſed them, and at the ſame time paſſed to the ſtate of ordinary muriatic acid, which fixed and retained in the liquor the greateſt part of the ureè, by defending it from the action of a freſh quantity of oxygenated muriatic acid. Here the influence of this reagent ended, ſtopped on the one ſide by the converſion of about one ſixth part of the ureè ſeparated from the water into carbonic acid and azot gaſes, and into a fat matter compoſing only two or three hundredths of this one ſixth decompoſed; and on the other ſide, by the ſaturation of five ſixths of this matter by the ordinary muriatic acid.

Ureè is very ſoluble in alkaline lixivia, and appears to have a ſtrong attraction for ſaline baſes. Triturated in a thick and ſoft ſtate with a lye of cauſtic potaſh, a ſtrong odour of ammonia is immediately perceived. Ureè treated by alkalis and ſalts.

The ſame takes place with the carbonats of potaſh or ſoda; and as lime, barites, and in ſome meaſure magneſia produces the ſame effect; it follows that this animal ſubſtance contains muriat of ammonia, which theſe baſes decompoſe. Another effect is, however, produced when ſolid or ſoft ureè is rubbed with dry cauſtic potaſh in powder. It's mixture becomes very warm, there ariſes ſo large a quantity of ammonia as to make it's formation evident; whilſt by the carbonats, it is only from the muriat contained in it. The mixture likewiſe, become of a very brown colour, lets a ſubſtance eſcape from it's ſurface, which is equally coloured, and has the appearance of an empyreumatic oil. From this it appears, that potaſh quickly decompoſes ureè, but it was neceſſary to procure a further decompoſition by heat.

One part of ureè in a ſirupy form, with two parts of pure ſolid potaſh, diſſolved in four times the quantity of diſtilled water, were poured into a tubulated retort, to which a receiver was applied filled one fourth full of wa- By potaſh with heat.

ter. It was then heated, and during the procefs it was found that the ureè was decompofed in a fimilar manner to that effected by the fulphuric acid, or the fpontaneous decompofition of ureè when it's folution is placed in a mild temperature. The ureè is changed into ammonia, and the acetous and carbonic acids; the benzoic acid is not changed during this decompofition, but is found amongft the diftilled products. Hence the extreme tendency of the ureè to be converted into ammonia, and carbonic and acetous acids, renders the power of the alkali of producing ammonia from animal fubftances more energetic and rapid, which thefe chemifts have called *ammoniazation*, and which arifes from the abundance of azot contained in ureè, and the fmall quantity of hydrogen; two circumftances which particularly characterize it, for in all the proceffes to which it is expofed, it is found to contain much more azot and lefs hydrogen than any other animal matter.

United with falts. According to thefe chemifts, the muriat of foda obtained from urine is in the form of octoedral cryftals, whilft that of ammonia is feparated in the form of cubes. Many errours arifing from chemifts having been deceived by their form, in taking the muriat of ammonia for that of foda, and the latter for the former, Fourcroy and Vauquelin found, after a great number of curious experiments, that the variation of their form, or the converfion of the primitive cube of the muriat of foda into an octoedron, and that of the primitive octoedron of the muriat of ammonia into a cube, is owing to the combination of thefe falts with the ureè. This property, the firft of the kind hitherto obferved, and which they confider as one of the moft extraordinary in the analyfis, fupplied them with a character of this animal matter; and it is a fact now well afcertained, that ureè diffolved in the fame water with the two muriats changes their natural form by

combining with each, and penetrating the laminæ of their cryſtals.

Recapitulation.

Although the chemical examination of urèe is at preſent very incomplete, and only comprehends it's analyſis, without the leaſt attempt at the ſyntheſis, it remains to collect in a rapid point of view the properties it preſented, and the means they afforded of determining it's nature, the proportion of it's principles, and a compariſon with other animal ſubſtances.

A. A ſhining cryſtallized maſs compoſed of yellowiſh lamellæ or tablets contracted in the centre, or of grains united and condenſed; it's deliqueſcent parts always brown; an immediate ſeparation from ſtrongly evaporated urine, on cooling, or from alcohol, containing it and ſimilarly evaporated and cooled; a garlic urinous odour, of an inſupportable fetidity, weakening thoſe who are for ſome time expoſed to it; a ſtrong, penetrating, and ſharp ſavour; adhering to the veſſels which contain it, and ſo hard as to be cut with difficulty; ſuch are the phyſical properties which characterize and diſtinguiſh it from other animal ſubſtances.

B. Quick fuſion, rapid intumeſcence by fire, volatiliization, and diſagreeable odour on being ſtrongly heated, eaſy deſtructibility by diſtillation on the open fire, enormous production of carbonat of ammonia, exceeding two thirds of it's weight, conſtant veſtiges of pruſſic acid, very little carbon, muriat of ammonia forming more than one ſixth of it's maſs, and ſome hundredths only of benzoic acid; ſuch is the manner of it's decompoſition by heat, which places urèe in an order of ſubſtances, of which no other analyſis by fire has given an example.

C. So ſtrong an attraction for water, which it immediately takes from the atmoſphere, as to become ſoft and melt on it's ſurface; a clammy and ſirupy ſtate, with a deep brown colour, owing to this deliqueſcence, ſo that

the difference between this honeylike portion, and the cryftallized portion beneath, might incline a perfon to think them not the fame; rapid folution in fmall quantities of water, it's various colour according to the proportion of water, from a reddifh brown and almoft black, to a lemon or flightly orange, which imitates at the will of the chemift every poffible urine, from the paleft to the higheft coloured; decompofition, converfion into carbonat of ammonia by hot water even before ebullition, provided it's action be long continued; thefe feries of phenomena give ureè a very diftinct place amongft animalized fubftances.

D. Very ftrong fermentation, when it's very diluted folution in water is mixed with an animal gelatinous or albuminous fubftance; fcarcely any when alone, and without any animal matter that can ferve as a ferment; formation of carbonat and acetite of ammonia, products of this fpecies of putrid fermentation, fource of the rapid putrefaction of urine, of the noifome odour it diffufes, and of the various fpecies of changes the different matters it contains undergoes; thefe, as well as the preceding characters, likewife ferve to determine the nature and properties of ureè.

E. Slow converfion into acetous acid and ammonia, by the fulphuric acid aided by heat; fudden precipitation by ftrong nitrous acid from it's concentrated folution into fhining lamellated and filkylike cryftals; flow decompofition; almoft perfect fufion into carbonic acid and azot gas, extremely abundant, and which are difengaged for a long time by the action of the weak nitric acid, affifted by a gentle heat; decompofition into ammonia and carbonic acid by oxygenated muriatic acid, and folution and prefervation by the common muriatic acid, which fhow it to be a very different compofition from other animal matters.

F. Laftly, rapid folution by potafh, and converfion into carbonat and acetite of ammonia, by the united action of a weak heat, and of fixed alkali; intimate union with the muriat of foda, the cubical form of which it changes to the octoedral, and *vice verfa*, with the muriat of ammonia; thefe leave no doubt on the peculiar nature of ureè.

The remarkable differences which ureè has prefented during it's analyfis are manifeftly owing to the great quantity of azot it contains, but to have a fatisfactory knowledge of it's nature, it is neceffary to determine the proportion of it's different principles. With this view, it has been found, that the products of it's diftillation anfwered to the refults of the other kinds of it's decompofition.

It has been before obferved, that 288 parts of ureè afforded by means of heat 200 parts of carbonat of ammonia, ten parts of carbonated hydrogenous gas, and feven of a coaly refidue, which with three parts of lofs, left 68 for the muriats of ammonia and of foda, and benzoic acid, matters which, although they conftantly accompany this fubftance, thofe chemifts regard as foreign to it's nature. Hence it is neceffary to reduce 288 parts of ureè extracted from urine by evaporation, and it's treatment by alcohol, to 217 of real urinary matter, 200 of which are converted into carbonat of ammonia, ten difengaged in the form of carbonated hydrogenous gas, and ten of fixed coaly refidue. Now 200 parts of carbonat of ammonia, fublimed and cryftallized, being formed of 90 of carbonic acid, 86 of ammonia, and 24 of water, and each of thefe three urinary compofitions being reduced to it's conftituent principles, it follows, on adding to the carbon of the carbonic acid the coaly refidue, with the addition of the three

Component parts of ureè.

quantities of hydrogen contained in the ammonia, in the water, and disengaged in gas, as well as that of the oxygen forming part of the water and carbonic acid, that the 217 parts of ureè really contain 85,2 of oxygen, 69,4 of azot, 32,2 of carbon, and 30,2 of hydrogen; which make very nearly for the 100 parts of this animal matter 39,5 of oxygen, 32,5 of azot, 14,7 of carbon, and 13,3 of hydrogen. It is, however, to be observed, that of the 39½ of oxygen there are about 11,0, which belong to the water perfectly formed, as well as two of hydrogen, so that the azot is the predominant principle of ureè, both as to the phenomena it presents, and in the proportion of it's constituent principles; hence the long effervescence it makes with the nitric acid, and the quantity of ammonia it affords in every species of it's decomposition; and although the hydrogen is in small quantity, it is more than sufficient to the formation of ammonia, and the excess is disengaged in a free state, carrying with it a little carbon, rather than enter into an oily combination, because the carbon finds a sufficient quantity of oxygen for combustion; thus there can be no oil, and in reality only a few slight traces of it are to be seen in the distillation of ureè. These circumstances prove it to be a composition ready to pass into the state of carbonat of ammonia whenever the equilibrium of it's parts is the least broken, and to be destroyed by the smallest efforts.

It's utility considered in a pathological view.

A knowledge of the properties and nature of ureè naturally leads to endeavour to find out the influence it may have in the animal œconomy, and in the theory and practice of the chemical arts, in which urine is employed.

The greater part of physiologists have looked upon urine as a saline lixivium, as the natural evacuation of the salts introduced into the system with the aliments, or formed by the actions of life. Boerhaave, however, regarded urine as an excretion of much more importance than

merely carrying away ſimple ſaline matters; he announced it to be a means of expelling the portion of our humours tending to putrefaction, and diſpoſed to bring the others into the ſame ſeptic decompoſition; but this beautiful idea of the Leyden profeſſor was not attended to.

The diſcovery of ureè by Fourcroy and Vauquelin, confirming in ſome reſpects the firſt idea of Boerhaave, correcting at the ſame time the falſe notion of an animal oil which he had conceived, affords a more exact explication of the urinary evacuation. It appears to be an excrement of a peculiar nature, and very different from any of the others. The great quantity of azot it contains evidently confirms it to be an evacuation of this principle, and in this reſpect, the kidneys may be looked upon by the phyſiologiſts as the excretory organs of the azot, in the ſame manner as the lungs are of the carbon and the liver of the hydrogen. Until this diſcovery, the way was unknown by which this principle was evacuated, which from it's preſence diſtinguiſhes and characterizes the animal parts, and conſequently is ſo apt to be ſuperabundant in the body. The myſtery is now unravelled. This azotic matter is ſeparated from the blood carried by the renal arteries, by which means the vital fluid, on loſing the ſuperabundance of this principle preſerves the equilibrium of it's compoſition ſo neceſſary to it. One of the moſt remarkable properties of ureè being the formation of ammonia, and this being one of the moſt characteriſtic products of putrefaction, it is natural that Boerhaave, who obſerved this abundant ammoniacal production in urine, ſhould have looked upon this liquor as charged with a matter extremely putreſcent, and as conveying out of the body the cauſe, which if ſuffered to remain too long a time would be productive of a ſeptic decompoſition. Although there is no poſitive experiment on the ſubject, it is very probable ac-

cording to these chemists, that when the ureè is not separated from the blood, the excess of it's elements, and especially of the azot in our humours, is very capable of giving rise to diseases, and particularly those of a putrid kind, since the present knowledge of chemistry attests that organic bodies are more susceptible of putrefaction according to the quantity of azot they contain, from the multiplied attractions it's presence produces in their component parts.

This function of the kidneys to deazotize in some measure the humours, and perhaps even the solids of the body, demands the attention of physicians; for the urine may be looked upon in future, not only as an evacuation of the superabundant phosphats, but of a matter very much disposed to the putrid ammoniazation; and it may be of consequence to be able to determine the proportion and the state of the ureè in this excrementitial liquid; to estimate it's different quantities, and it's nature in different diseases; to determine more particularly the specific gravity of the urine, where the ureè, five or six times greater in quantity than all the other salts which this fluid holds in solution, has the greatest influence; to seek in the degree of colour the proportion of this substance; to analyze it where this matter appears to be entirely wanting, as in hysteric or hypochondriac diseases, and convulsive and nervous affections, and where it is more abundant than usual, as at the end of some fevers, in diseases of the liver; and lastly, to examine it's relations with the uric acid, a great abundance of which Scheele had observed in urine at the time of a crisis. Researches like these may be very important in the solution of many phenomena relating to pathology, which at present are not to be explained, although these two chemists have made the attempt. It is their opinion, that when urine remains too long in the bladder, as in retention, it con-

tracts an ammoniacal acridnefs, which is manifeft from it's ftrong fetid odour, and brown colour on being evacuated by art; that it is to this formation of ammonia the infupportable pain is to be attributed which thefe patients often experience; and this is proved by the injection of water flightly impregnated with ammonia into the urinary canal, an experiment which Dr. Swediaur found to be a good imitation of the blennorrhagia from the irritation and mucous fecretion it excited.

In old people, where the fenfibility and irritability of the fibres of the bladder are weakened, and who often die in confequence, the urine which remains too long a time becomes in the fame manner ammoniacal and fetid; it flows in a turbid, vifcous and ropy ftate, from the gelatinous mucilage which the addition of ammonia feparated from the acid that holds it in folution in the natural ftate. The fame phenomena fometimes take place in the pains and urinary ftoppage occafioned by the prefence of a calculus in the bladder. The urine after calculous tortures is often rendered thick, and in fome points glairy as glue, the chemical effect of the ammonia formed, and of the feptic change the ureè has already undergone in the bladder. The fame happened with three calculous patients, to which thefe two chemifts had adminiftered by injection a very diluted folution of potafh; the urine flowed glairy, and fo loaded with flocks as fometimes to ftop the catheter. Four patients with the gravel, for which they took for feveral days a few drops of lye of potafh in fome linfeed water, had their urine rendered equally thick and ropy from the action of the alkali upon this liquid.

It's application to the arts.

With refpect to the application of the difcovery of urée to the arts, it may be divided into four principal parts. 1. The artificial formation of nitre. 2. The employment of urine in the procefs of fcouring woollens.

3. The extraction of ammonia. 4. The extraction of muriat of ammonia from it.

1. In making nitre. 1. Manufacturers of saltpetre have long ago observed, that soft stone, arable ground, earth impregnated with urine, soon became loaded with this salt: hence they preferred materials of this nature to all others. Thus in Switzerland and Sweden the urine of cattle is made use of in the formation of saltpetre, and in several artificial nitre manufactories in France, the earthy mixtures, and the relics of vegetables and animals for that purpose, are moistened with urine; from which it is evident, that this liquid contributes to the formation of the nitric acid, from the considerable quantity of azot that enters into the composition of ureè, one of it's properties not to be exceeded by any other natural substance. The contact of the atmospheric oxygen, and of several vegetable matters, appears to prevent, in the making of saltpetre, the formation of ammonia in ureè, and to determine that of the nitric acid.

2. Scouring cloths. 2. The ancients made much more use of urine in cleansing woollen stuffs, particularly white ones, than the moderns; and it appears that for this purpose it was necessary to keep it a longer or shorter time before it was ready. It was anciently collected in Rome, as mentioned by Pliny, Martial, Macrobius, &c. for the use of scourers, who were obliged to reside either in the suburbs or in some of the frequented streets, from the nuisance the putrid urine occasioned. According to Suetonius, the emperor Vespasian put a tax upon it, as his historians tell us, *urinæ vectigal commentus est*: it continued two centuries, till the time of Anastasius; and we read also of *vectigal pro urina jumentorum et canum*, which was exacted from every person who kept cattle. It is collected for the cloth manufacturers at Leeds, Halifax, &c. under the name of *old lant*.

Every thing proves that the putrid urine thus ufed acted by the ammonia that was formed, and that it was preferable to fixed alkalis, as they were known to change the texture of the wool, whilft ammonia does not fenfibly affect either it's ftrength or it's nature.

3. The art of extracting the *ancient volatile falt*, or the carbonat of ammonia fublimed from urine, has been long known. It was practifed towards the end of the feventeeth century; and the theory is well explained from a knowledge of the nature of urine. It is well known to afford it in large quantity after putrefaction; but it is neceffary to remark, on it's ammoniacal converfion, that when urine has been ftrongly evaporated, and to drynefs, it no longer gives fo much carbonat of ammonia by fermentation, even if the fame quantity of water be added as exifted before. This arifes from the feparation and deftruction of a gelatinous or albuminous animal matter during the evaporation, which before ferved it as a ferment, and enforced the formation of the ammonia; whilft abandoned alone, and without a ferment to it's fpontaneous decompofition, the ureè which undergoes it difficultly and flowly, in part paffes to the ftate of acetous acid, which diminifhes in proportion to the quantity of ammonia. Hence the great advantage of letting the urine become putrid, inftead of evaporating it when frefh in order to obtain the carbonat of ammonia. Making of ammonia.

4. Laftly, the extraction of muriat of ammonia, although fome chemifts, and efpecially Rouelle, junior, nearly denied the exiftence of it in human urine, having been concealed by the cubic form which the ureè gave it. This is eafily feparated from the refiduum after the urine is advanced in putrefaction, by means of heat, being found almoft in an ifolated ftate; befides, the ufe of carbonat of ammonia, fo abundantly furnifhed by this fermented liquor, in decompofing earthy muriats, 4. Extraction of muriat of ammonia.

may be confidered as fingularly increafing this production of ammoniacal muriat, and in this refpect the natural decompofition of ureè or urine is one of the moft rich and ufeful materials in the manufactures of falts.

URINE OF THE HORSE, &c.

Urine of the horfe.

It is a very peculiar fact, and firft announced by Rouelle, that the urine of animals which feed on vegetables contain no phofphoric acid, but a much greater quantity of extractive matter than the human. Giobert, on the contrary, affirms that the urine of horfes is nearly as proper for the making of phofphorus as the human; but he has not fupported his affertion by any pofitive experiment, and Fourcroy has proved that the acid which fupplies the place of the phofphoric is the benzoic.

Examined by Rouelle.

According to Rouelle, the urine of the horfe has a peculiar fmell, approaching very much to that from the cow. It is in general turbid, either when firft voided, or a little after; expofed to the air, it foon becomes covered with an earthy pellicle, which, when broken, falls to the bottom, and is fucceeded by another that continues feveral days; twelve pints of urine often afford fix or feven ounces of this pellicle. This urine is very pituitous, which quality it lofes on being boiled.

It always changes the blue of violets to a green, and both the mineral and acetous acids effervefce with it. The foapy extract is in large quantity, the extractive matter is much greater in quantity than in the human, and that of the cow, and is black. This chemift extracted neither muriat of ammonia, nor phofphoric falt from it, but like thofe of the cow and camel, he obtained the digeftive falt of Sylvius, vitriolated tartar, and calcareous earth, which he converted into lime.

The urine of the horse has been examined by Fourcroy and Vauquelin; they found that it contained a great quantity of benzoat of soda, combined with an oily matter approaching to a resin; that the nitric acid precipitated some white silky crystals from it's alcoholine solution, the nature of which is unknown; and that this urine is composed of By Fourcroy and Vauquelin.

0.011 of carbonat of lime, held in solution by the carbonic acid.
0.009 of soda.
0 024 of benzoat of soda.
0.009 of muriat of potash.
0.007 of a peculiar animal or vegetable matter.
0.940 of water, mucilage, but no lithic acid.

The urine of the cow, when fresh, has, according to Rouelle, a very strong peculiar smell, it has in general little colour, but becomes deeper on being kept; it has then nearly the beautiful amber colour of the human. It is often turbid as well as that of the camel, from the quantity of matter it contains beyond the point of saturation. It changes the sirup of violets green, and if exposed twenty four hours to the air, very singular crystals are formed on the surface; it effervesces with acids from the free vegetable alkali it contains; the volatile and fixed alkalis have no effect upon it. It contains the saponaceous and extractive matters like the human, but the first affords more oil and no muriat of ammonia, the remainder is alkaline, and effervesces strongly with acids, which is not the case with the human; with respect to the second, it is more abundant, and on analysis, affords the same as the first, viz. volatile and fixed alkalis. Urine of the cow and camel, by Rouelle.

The same chemist obtained from the urines of the cow and camel, which resemble each other in many points, a free vegetable alkali, vitriolated tartar, digestive salt of

Sylvius, but no phofphoric falt, at leaft he could obtain none by the ordinary methods.

He alfo got from the urine of the cow, not conftantly, but at three different times, a volatile acid falt in fmall needles, or very light filvery fhining leaflets, which fublimed like the flowers of benzoin, and refembled them in tafte. It is little foluble in water, but very much fo in alcohol and ether. It changes the firup of violets to a beautiful red colour, unites to fixed alkali with effervefcence, and is either decompofed or difappears from putridity, fince putrid urine never afforded this falt.

SWEAT.

A great analogy has been found to exift between the fluid emitted by cutaneous perfpiration and urine, and it has been obferved, thefe excretions mutually anfwer the fame purpofe in many cafes, and we are therefore naturally led to confider this vaporous fluid as of the fame nature as urine. Phyficians have found that it's qualities are fubject to variation; that it's odour is faint, aromatic; that it is alkaline, four; that it's confiftence is fometimes glutinous, thick, tenacious; that it leaves a refidue on the fkin, and that it often tinges linen with various fhades of yellow. Very few chemical experiments have been made upon this fluid; Berthollet affirms, that it reddens blue paper, and that this effect is produced more particularly from that which is procured on thofe parts affected with gout. He thinks it contains the phofphoric acid; and Henckel faw a perfon whofe body during perfpiration was become phofphorefcent.

Pliny's Natural Hiftory.—Macquer's Wœrterbuch von Leonhardi, art. Harn.—Fourcroy's Elements, vol.

4. Englifh Tranfl. art. Urine. 1788.—Haller's Elementa Phys. art. Urina.—Rouelle in the Journal de Méd. tom. 40. Nov. 1773.—Encyclop. Méthod. Chimie. tom. 1. p. 204. art. Acide Ouretique.—Sur le Sel fufible entiere extrait de l'Urine humaine, par M. Fourcroy. An. de Ch. tom. 7. p. 183. — Prouft in Rofier's Journal de Phys. 1781.—Klaproth ueber die Natur des Prouftifchen fogenannten Perlfaltzes, in Crell's Chem. An. 1785.—Berthollet fur l'Acide Phofphorique de l'Urine, in the Mém. de l'Acad. de Paris. 1780. — Mémoire fur la Nature de Rachitis. An. de Ch. p. 113. tom. 18.—Gaertner. vide ibid. No. 71. p. 170.—Halle Obfervat. fur les Phénom. et Variat. qui préfente l'Urine confiderée dans l'Etat de Santé, Mém. de l'Acad. p. 469. 1779.—Brugnatelli ueber den Bodenfatz des Harnes in Crell's Chem. Annalen. An. 1787.—Experiments and Manner of diftinguifhing feveral Difeafes by the Urine, by Mr. Cruickfhank. Philofoph. Mag. No. 7. Dec. 1798.—Mémoire pour fervir à l'Hiftoire Naturelle Chimique et Medicale de l'Urine humaine, &c. par les Cits. Fourcroy et Vauquelin. An. de Chim. p. 80. No. 94. & p. 113. No. 95.

FÆCES.

The fæces not only vary in their conſiſtence in different animals, but even in the ſame animal at different times, and this variety is found to paſs through all the degrees, from a fluid ſtate nearly to a firm ſolidity. The colour is equally variable: in man it is more or leſs yellow; in quadrupeds, as the horſe and cow, it is a dark green; in the pig it is grayiſh; in the dog it is ſometimes white, at other times black; in ſome kinds it is white like chalk, as in thoſe particularly that live by ſuction, viz. the woodcock and ſnipe; in ſome inſects it is red, as the bug and flea, whilſt in others it is green.

Their great variety.

The odour alſo is various. It is generally more or leſs fetid, but in the cat it is extremely ſo, and more ſo in the carnivorous than graminivorous animals; whilſt in thoſe of ſome animals there is ſcarcely any ſmell.

Since the fæces are the refuſe of the food, by which animals are ſupported, it is natural, however, to ſuppoſe that theſe differences muſt ariſe from the nature and properties of the food the animal takes in; and this difference of food will equally have an influence on them when ſubmitted to chemical analyſis. With reſpect to their colour, it generally ariſes from a portion of bile they contain; and as to their fetid odour, Fourcroy is of opinion it ariſes from the commencement of a putrefaction, which already takes place during their paſſage through the inteſtines, although ſome chemiſts will not allow of any ſuch putrefaction.

Some of the old alchemiſts had an idea that the philoſopher's ſtone was concealed in animal fæces, and on this account, many experiments have been made, parti-

cularly upon the human, and thofe of quadrupeds; but from the great obfcurity that is thrown over their writings, nothing fatisfactory is to be learned from them. The only chemift, according to Macquer, who has inveftigated the nature of human fæces, is Homberg, and this unpleafant operation he undertook for the fatisfaction of a friend, who affirmed, that a white oil, of no unpleafant odour, was to be extracted from them, which poffeffed the valuable property of fixing quickfilver in fuch a manner as to be converted into filver. Homberg found the oil, but it had no fuch effect on quickfilver. Human.

Frefh human fæces, diftilled on a water bath, even to drynefs, afforded nothing but an aqueous, clear, taftelefs fluid, of a difagreeable fmell; no volatile alkali, however, appeared, although it had approached to a putrid ftate, whilft putrid fubftances always afford it at the fame heat.

The dry refidue, on increafing the heat by degrees, gave a volatile alkaline fpirit and falt, a ftinking oil and a carbonaceous portion remained, confequently the fame fubftances as other animal matters.

The fame fort of fæces lixiviated with water, filtered and evaporated, afforded an oily nitrated falt, which fufed on red hot coals like faltpetre, and heated to a certain point in clofe veffels, inflamed. Putrid excrements gave an oil without colour or fmell. To this it may be added, that the fæcal matter which Homberg analyzed, was from a perfon who had been fed on coarfe bread, and Champaigne wine.

We learn from Haller, that the human fæces contain a fmall quantity of acid, which is found in greater abundance in the ruminating clafs; and Brugnatelli fpeaks of an acid exifting in the fæces of carnivorous birds; thofe of the dog, however, contain none of it. Thofe of ruminating animals likewife effervefce with the nitrous

acid, which is produced in a much ſtronger degree with the fæces of the dog, hen, and pigeon. In ſome countries it is not uncommon to make uſe of pig's dung inſtead of ſoap.

MECONIUM.

THIS is the matter contained in the inteſtines of the fœtus, that has not reſpired, and which is rendered by infants a few hours after their birth. It is particularly found in the large inteſtines, in the duodenum, and even in the ſtomach; it is ſometimes in conſiderable quantity. It is conſequently the firſt excrement that is formed, and it's origin has been almoſt always attributed to the bile.

It is of a brown, greeniſh brown, or black colour, of the conſiſtence of liquid honey, or pretty thick ſirup, is viſcous and ropy. It is generally without any odour or ſavour, but ſometimes it is ſlightly fetid.

Bordeu appears to have been the firſt who has particularly attended to the meconium; he has inſerted into his medicinal analyſis of blood the examination of this matter, made by Bayen and Deleurye, and it is from this article that Fourcroy, in his *Syſtème des connaiſſances chimiques*, has collected his materials for this ſubject, of which the following is an account.

Examined by Bordeu. According to Bordeu, the meconium is commonly without any odour, but ſometimes it has a diſagreeable, earthy, mouldy ſmell; it is black in the large inteſtines, and greeniſh in the others; it is more of a mucous than oily nature, appearing to him to be uninflammable; there is no predominant mark of acidity or alcaleſcency; it has, however, a ſaponaceous character, being both ſoluble in water, and in alcohol. He looks upon it as a

ftercoral matter, as the firft attempt of the action of the inteftines.

After Bordeu, Bayen made an analyfis of this matter, and although his refearches did not extend to any great degree of minutenefs, they are fufficient to give an idea of it's general properties. This liquid, analyfed by Bayen, was of a deep olive colour, without odour, and almoft without any favour, and of the confiftence of an electuary, or thickened mucilage. It tinged linen yellow, and this colour could not be extracted by water, although it took the fame yellow tinge. Diluted with fixteen times it's weight of water, it communicated it's colour to it very flowly, and more than one half of a grofs matter was precipitated, that on exficcation became brown. Heated in an iron fpoon, it fwelled, emitted at firft an aqueous, then an oily vapour, but always of a lefs difagreeable fmell than that of other animal fubftances; it did not, however, inflame, although the fpoon was red hot. Exficcated on the water bath, it loft more than four fifths of it's weight, and became a brown, opake mafs, eafy to pulverize, exhaling a mild agreeable odour, refembling that of evaporated milk; it was fomewhat bitter. A little of this dried meconium, digefted with ten times it's weight of alcohol, gave it a deep yellow colour, and when evaporated, about one tenth of it's weight was left of a faffron yellow matter, bitter and tranfparent, perfectly refembling that which is extracted from bile by the fame means. The refiduum, undiffolved by the alcohol, was black, although it gave to water a yellow colour. The greateft part of the dried meconium, heated in a fmall glafs retort, afforded half it's weight of water, about one half of oil, fome carbonat of ammonia, and an elaftic fluid, which Bayen looked upon to be air. A coal remained, forming one fixth of the mafs; which, on being roafted, afforded ftill more ammonia, became

Bayen.

incinerated on it's surface, and hard at it's centre, although exposed to a red heat five or six minutes, and this is the case with all animal charcoal. When roasted longer, it became friable, although it remained black; it had lost somewhat less than half it's weight, and effervesced with the nitrous acid. From these experiments, Bayen concludes, that the meconium is a real excrement, but milky, and already mixed with bile like that of adults.

Deleurye. Bordeu has likewise given some observations of Deleurye on this matter, which to a certain point are opposite to those of Bayen, as they announce a fetid odour, whether from this liquid when heated by itself or with water. The same person has observed, that in many infants that died at birth, and from which he collected the meconium, he found the gall bladder containing a liquid more inclined to a reddish colour than that of the bile; in fœtuses dead before they had respired, he found no liquid in the stomach, only a gluey, reddish coat, and the same in the small intestines; in the cœcum the coat was white and thick; in the colon it was still thicker, but brown and resembling the meconium, particularly near the rectum. The internal coat of the colon was spotted with the brown shade of the meconium, and very difficult to clean; the rectum was full of viscous meconium, difficult to take away, and it obstinately preserved the colour of this excrementitious liquid.

These facts Bordeu thinks are sufficient to conclude the meconium to be the purest part of the bile, accumulated in the liver, becoming black in proportion as it loses it's water, tinging all the membranous parts to which it adheres of a yellow colour, emitting particular emanations to the surrounding parts, mixed with mucous, stomatic, and pancreatic humours, and forming a column of matter upon which the intestines are moulded, and from which they take their form.

The enlightened chemift needs not be informed, that the experiments and obfervations on this matter are at prefent infufficient, to produce any fatisfactory conclufions as to the ufe of it in a pathological point of view.

It now remains to give fome account of the experiments on the dung of other animals.

Vauquelin having obferved the great quantity of carbonat of lime, which is daily formed in the oviduct of hens that lay, and the extreme quicknefs with which this earth is depofited upon the fubftance of the egg, was induced to make fome experiments on this fubject; being convinced that this matter was previoufly feparated from the blood by the kidneys, and afterwards carried into this organ by fome liquid that ferves it for a vehicle.

Vauquelin's experiments on the excrements of poultry.

On calling to mind that the urines of the cow, the horfe, the camel, the rabbit, and in general of all *herbivorous animals*, contain carbonat of lime, without any mixture of phofphat of lime, and that this laft remains almoft wholly in the refiduum of digeftion; it will not be aftonifhing, that hens which are nourifhed with matters of the fame nature fhould only furnifh carbonat of lime in their urine, particularly on reflecting that their burnt excrements only contain very little of this calcareous falt, and fcarcely any thing but phofphat of lime, although their aliments afford much more carbonat of lime than phofphat. It appears, therefore, that during the act of digeftion, fome carbonic acid is formed from the alimentary fubftances, which diffolves the lime, and favours it's paffage into the circulation, from whence it is afterwards feparated by the kidneys, and carried into the oviduct, where, by a peculiar affinity, it attaches itfelf to the fubftance of the egg.

Vauquelin found that nine egg fhells weighed, according to the new weights, 44,796 gramms, which, divided by 9 = 4,997 for each fhell. Thus a hen which has

Weight of fhells.

laid 90 eggs in four months and a half, must have formed in that time 447,959 gramms of carbonat of lime, excepting the deduction of the gluten, which unites the calcareous parts.

Quantity of animal gluten.

These 44,796 gramms of egg shells, calcined to blackness, lost 8,321 gramms; the residuum dissolved in the nitric acid with great effervescence, and with an odour of sulphureous hydrogen, there remained 0,217 gramms of coal.

The nitric solution was white; having boiled it a sufficient time to deprive it of the carbonic acid that might have combined with it during the solution, some ammonia was mixed with it, and 0,58 of a gramm of phosphat of lime were obtained; thus there remained 40,178 gramms of carbonat of lime, from which it appears, that 1000 parts of egg shells are formed,

1st, of carbonat of lime	....	896
2d, of phosphat of lime	....	57
3d, of animal gluten	....	47
Total	....	1000

Medium weight.

The weight of eggs vary according to the sort of hen, according as the laying is more or less accelerated, and various other circumstances; but from a number of experiments Vauquelin fixes the medium term at 58,117 gramms. Hence a hen that has laid 130 eggs in six months, which is pretty common, has formed 7486,226 gramms, or 7 kilogramms, 4 hectogramms, 8 decagramms, 6 gramms, and 226 thousandths of a gramm of matter employed in the formation of these eggs, of which 641,685 gramms are to be subtracted for the shells; there remain then for the substance of the egg itself 7333,793 gramms, or 14lb. 15oz. 7drs. 8grs.

Dung of the hen and cock compared.

When the dung of the hen is attentively compared with that of the cock, the first is observed to be blacker,

and infinitely more meager and exhausted of nourishing matter than that of the cock. Besides this last contains a great quantity of a white cretaceous-like matter, which covers it, although easily detached from it.

Vauquelin had, at first, supposed this white matter to be phosphat of lime, because it dissolved in acids without effervescence; but other circumstances, to be related, soon changed his opinion.

Equal quantities of hen's and cock's dung were calcined in two different crucibles; the first left 5;201 gramms of residuum, and the last only 3. Their ashes dissolved in nitric acid without effervescence; but that of the hen emitted an odour of sulphureous hydrogenous gas.

The residuum of that of the hen, insoluble in nitric acid, was 2,335 gramms, and of the cock, 1,06 gramm, and were nothing but fragments of stone and sand, mixed with a small quantity of coal that had escaped combustion.

Quantity of phosphat of lime in both compared.

The filtered solutions of these two sorts of ashes afforded very abundant deposits by the addition of ammonia, which proves that the matter dissolved by the nitric acid was phosphat of lime. The precipitate furnished by the excrement of the cock weighed 1,166 gramm, and that of the hen two gramms.

Having thus separated the phosphat of lime from the nitric solutions by ammonia, which, after this last, produced no further change in them, the carbonat of potash gave rise to new precipitates, which were carbonat of lime, the weight of which, in that of the cock, was 0,265 of a gramm, and in that of the hen, 0,185 of a gramm.

It follows therefore, first, that in the excrements of these animals, besides the phosphat of lime, there remains carbonat of lime. Secondly, that if these burnt excrements did not effervesce on being dissolved in acids,

it arifes from the carbonic acid having feparated from the lime during calcination.

Reflections. The refult of thefe experiments feems contrary to what reafon might indicate, for if a part of the calcareous earth ferves to form the envelope of the egg in laying hens, their excrements ought to contain proportionally a lefs quantity of this fubftance than thofe of the cock; but on recollecting that hens, during this epoch, take at leaft two or three times more food than the cock, that the excrements of the firft are much more abundant, more meager and more exhaufted, it will be eafily conceived how it may happen, that befides the portion of calcareous earth employed in the formation of the egg fhell, there ftill remains more in their excrements than in thofe of the cock. Hence a hen that has layed 130 eggs in the fpace of fix months, the weight of which amount to 7333,793 gramms, deducting the weight of the fhells, has need for the formation of this animal matter of a greater quantity of nourifhment, in part ufelefs to the cock, and confequently his excrements ought to be more abundant, more meager, and more charged with calcareous matter.

But it may be faid, if the carbonat of lime tends towards the oviduct in the female at the time of laying, it ought to be formed, and afterwards found in the excrements of the male, having no organ to difpofe of it, and yet thefe excrements do not afford a greater quantity than thofe of the hen.

This objection Vauquelin oppofes, by what has been faid before, relative to the quantity of nourifhment compared to that of the cock, which the hen has need of during her laying, and by what will be laid down hereafter on the comparifon of the excrements of the hen when fhe lays and when fhe does not.

Although the quantity of carbonat of lime appears ſufficient in general for the formation of the ſhell; it is not, however, inexhauſtible, for it has been obſerved, that when the laying is accelerated, the ſhell is much lighter, and very often the eggs are only covered ſimply with a membrane; hence it appears, that the calcareous matter in this laſt circumſtance is not formed in the ſame proportion as the matter of the egg itſelf.

There are likewiſe circumſtances where the calcareous matter is more abundant than neceſſary for the formation of the envelope, for it is not rare to ſee a hen that has layed in the morning lay another egg in the evening, which is very ſmall, and with a thick ſhell, and only filled with a white tranſparent glare, without any yolk. Hence it appears, that when the deſcent of the egg from the ovary into the oviduct does not take place ſoon enough, the albumen becomes covered, by a peculiar affinity, with the calcareous matter, and forms a ſpecies of ſterile egg.

Excrements of laying hens compared with others, and with thoſe of the cock. It is very well known, that at the time of laying, hens eat much more than at any other ſeaſon of the year, that the cock collects for them food, calls and invites them to eat, by a peculiar language; that their excrements are infinitely more abundant and more exhauſted than thoſe of the cock. It has likewiſe been obſerved, that during laying, hens render none, or ſcarcely any of that white cretaceous-like matter which covers their excrements at other ſeaſons, whilſt the cock renders it always; but that as ſoon as the hen begins to ſit, this matter reappears; and further, as they only render their excrements at very diſtant intervals, they evacuate a pretty large quantity of a clear liquid, ſeparated from the excrements, which ſoon after becomes turbid, and depoſits a white matter that effervesces with acids; it contains carbonat of lime.

Matter The white cretaceous-like matter abovementioned, which

which covers the dung of the cock, and hens which do not lay. envelopes, or fimply accompanies the dung of the cock, and of the hens that do not lay, fubmitted to different experiments, has the following properties,

It's properties. 1ft. It is infoluble in cold, and boiling water.

2d. It burns in the fire like animal matter, and leaves fcarcely no refiduum.

3d. It diffolves in the nitric and muriatic acids, without effervefcence, and it's folution affords no precipitate by alkalis, whether cauftic or faturated with carbonic acid, it only becomes of a yellow colour.

4th. It's folution in acids forms with tan contained in the infufion of gall a very abundant white precipitate.

Thefe properties prove this fubftance to be of an animal nature; it is not, however, gelatin, fince it would have been foluble in boiling water, although perfectly dry, and fince there is only this and albumen fufceptible of uniting with tan, and forming a combination infoluble in water, it is evidently a real albumen, or white of egg coagulated and dried by the air. "Hence," fays Vauquelin, "although the cock does not lay, there is a fubftance prepared in his organs, proper to form the white of egg, and henceforth, it will, perhaps, not be ridiculous to believe, that thefe animals, under fome circumftances, may render a fpecies of egg, and the opinion of the country people be no longer a prejudice. It is fufficient, that a certain quantity of glair or *albumen* fojourn a certain time, and the urine on paffing cover it with carbonat of lime, with which it is faturated. I confefs I never faw this phenomenon; but fo many people are faid to have feen it, that it is difficult not to believe fomething of it."

Earthy refiduum of burnt oats examined. Vauquelin, in order to determine more exactly what took place during digeftion in thefe animals, endeavoured to find out the principles oats are compofed of, with which they are nourifhed, and in what proportions they

exiſt. This view in particular was to determine what relations the earthy parts bore to each other, ſuch as the lime and the phoſphat of lime. He found that oats contain about 0,031 their weight of aſhes, on incineration, and that theſe aſhes are compoſed of 0,393 of phoſphat of lime, and 0,607 of pure ſilex. This chemiſt looks upon it as ſomewhat extraordinary, that he did not find any mixture of alcali or calcareous earth with the phoſphat and ſilex.

Having determined the nature and proportions of the earthy matters contained in oats, he was deſirous of knowing the changes theſe earths had undergone by digeſtion. On which account he encloſed a laying hen in a place, and gave her oats, of which he knew the weight. In the ſpace of ten days, the hen had eaten 483,838 gramms of this feed, and had laid four eggs. Reſiduum of hen dung produced by oats and burnt.

Having collected and dried the excrements, he incinerated them in a crucible of porcelain, and found the aſhes to weigh 38,957 gramms. Theſe aſhes were in part diſſolved by the muriatic acid without efferveſcence, but there aroſe a ſtrong odour of ſulphureous hydrogenous gas. When the acid had ceaſed to act on the matter, it was diluted with water, filtered, and the reſiduum edulcorated, it weighed 8,492 gramms; ſome cauſtic ammonia was then poured into the muriatic ſolution, which formed a very abundant white precipitate, and weighed, when waſhed and dried by a read heat, 7,643 gramms. This matter ſubmitted to different experiments preſented all the characters of phoſphat of lime, without any mixture of foreign matter.

The liquor (ſeparated from the phoſphat of lime) mixed with the common carbonat of potaſh, gave a white precipitate in large quantity, which weighed 2,547 gramms when dried.

The formation of a conſiderable quantity of carbonat Remarks.

of lime that did not exiſt in the oats with which the hen was nouriſhed, is a circumſtance very important both with reſpect to the theory of the formation of the ſhells, and for the economy of granivorous animals in general. It is not leſs remarkable, that the quantity of phoſphat of lime obtained in the excrements of the hen, furniſhed by 483,838 gramms of oats, is much greater than what the ſame quantity of oats afforded by combuſtion, which out of 15,285 gramms of reſiduum, gave 5,944 gramms of pure phoſphat of lime. Hence it would appear, if the experiments of Vauquelin are exact, that,

1. A portion of lime was formed during the act of digeſtion, and of the animalization of the oats.

2. That a portion of phoſphoric acid was likewiſe formed.

3. That a certain quantity of carbonat of lime was equally generated.

In reality, 2,547 gramms of this laſt ſubſtance were obtained from the excrements of the hen, whilſt the oats afforded none; and beſides, the hen laid four eggs during the time of eating the oats, the ſhells of which weighed about 19,744 gramms, which with the 2,547 remaining in the excrements, form 22,291 gramms, or five drachms, ſix grains; a very conſiderable quantity. It cannot, however, be ſuppoſed that this carbonat was formed at the expenſe of the phoſphat of lime contained in the oats, for it is to be recollected, that only 5,944 gramms were obtained from 483,838 of this feed, and that the excrements ariſing from the ſame quantity of oats gave 11,944, which makes a difference of ſix gramms.

Thus the excrements of a hen which had only eaten 483,838 gramms of oats, in ten days, afforded on ana-

lyfis 2,547 gramms of carbonat of lime, which added to the 19,743 gramms, forming the fhells of the eggs laid during the interval, make 22,29 gramms, of which not a particle exifts in the oats.

They likewife furnifhed 11,944 gramms of phofphat of lime, whilft 483,838 gramms of oats only gave 5,944. Hence there was an increafe of fix gramms; a very confiderable quantity.

Quantity of filex in the oats with that in the excrements.

Vauquelin endeavoured to find, in the refiduum of the burnt excrements of the hen, infoluble in acid, the origin of this carbonat of lime, which is not found in oats, as well as the increafe of the phofphat of lime, a part of which only exifts in that feed.

For this purpofe he took the 8,492 gramms, or 160 grains of refiduum, (left after the muriatic folution was diluted) as before mentioned. Thefe were formed with three parts of cauftic potafh, in a filver crucible, and after being properly treated, 8,067 gramms of pure nitre were extracted from them.

The 0,425 of a gramm deficient muft be attributed to the carbonated matter that coloured the refiduum.

On comparing, therefore, the refiduum of the excrements of the hen with that of the oats, refpecting the filex, it appears that it contains 1,274 gramm lefs of filex, fince 483,838 gramms of oats furnifhed 9,342 gramms of this earth, whilft the excrements arifing from the fame quantity of this feed only afforded 8,067 gramms.

It appears from thefe experiments, that whether the fmall quantity of filex found in the nutriment of the hen, gives rife to the calcareous matter of the excrements or not, it is certain, that a confiderable quantity of lime, both in a ftate of carbonat and phofphat, is generated in the organs of that animal, whilft a portion of filex is found to have difappeared, which feems to

be in too inconſiderable quantity to give origin to ſo great a maſs of calcareous earth, (the ſilex being only 1,274 gramm, the calcareous matter 14,118 gramms). But although the concluſions are little ſatisfactory, the reſults of the experiments merit a farther conſideration; and ſhould future ones confirm them, it will oblige the chemiſt to admit, that ſilex is changed into lime during the digeſtion of poultry.

Macquer's Chém. Wœrterbuch von Leonhardi. p. 134, t. 2.—Fourcroy's Syſtème des connaiſſances chimiques, &c. par A. F. Fourcroy, Art. Meconium, t. 10. Paris, An. 11.—Expériences ſur les Excrémens des Poules, comparées à la Nourriture qu'elles prennent, et Réflexions ſur la Formation de la Coquille de l'Œuf, par le Cit. Vauquelin, Annal. de Chimie, p. 3. tom. 29. An. 7.

COMPONENT PARTS.

On taking a view of the analyſis of the different parts of the animal body, and particularly that of the fluids, ſolids, hard and external parts, it appears from the preceding experiments, that beſides water, which is more or leſs common to all bodies, there are four principal ſubſtances that predominate in their compoſition, and it is from theſe more particularly, that the different organs have their origin. Theſe four ſubſtances are, albumen, gelatin, fibrin, and oſſeous matter; and the following are their characters and properties, according to chemical analyſis.

ALBUMEN.

Animal albumen is generally found in the form of a tranſparent fluid, more or leſs viſcous, and of an aqueous colour, tending to a yellow.

It's ſavour is ſlightly ſaline, and if taſted with attention, ſomewhat ſharp. It's properties.

It changes the ſirup of violets green.

It is ſoluble in cold water.

Alkalis diſſolve it.

Acids coagulate it.

Lime water produces a precipitation in the albumen, which is the phoſphat of lime. It is coagulated by the metallic oxyds, and by alcohol.

It decompoſes, and cauſes a precipitation in ſolutions of neutral, calcareous, and metallic ſalts.

It undergoes the putrid but not the acetous fermentation.

The moſt diſtinguiſhing character of this fluid is, that when expoſed to a degree of heat from 45° to 48° (80° being the boiling point) it's liquidity and tranſparency diſappear, it becomes opake, white, concrete, and ſolid. On examination, during this change, there is a fibrous appearance, but as ſoon as the coction is complete, the whole is homogeneous, white, and ſolid; and on exſiccation, it is brittle, ſhining in it's fracture, and tranſparent. A great degree of heat diſengages ammonia from it, and a very fetid oil, as from other animal ſubſtances.

Oxygenated albumen, it's properties.

This concretion of albumen by heat is, according to Fourcroy, one of the moſt remarkable phenomena, animal ſubſtances preſent to the chemiſt; and from a number of experiments made upon it, with Vauquelin, he attributes it to the abſorption and fixation of oxygen, for which the heat increaſes it's affinity. In this ſtate he calls it oxygenated albumen. It is then of a white colour, and has changed it's properties; for, according to Fourcroy, ſolid or oxygenated albumen is no longer ſoluble in water; Hatchett, however, found, that in a ſlight degree, inſpiſſated albumen is ſoluble. It is inſoluble, however, in cauſtic alkalis.

Concentrated acids produce different effects upon it. The concentrated ſulphuric acid reduces it to a charcoal by combuſtion, during which a diſagreeable odour is emitted. The nitric acid at the temperature of 15° diſengages azot gas from it, and if the mixture be heated, pruſſic acid is formed, flying off in the form of a gas, recognized by the odour of bitter almonds; afterward a portion of the charcoal is ſeparated, which united to it's oxygen forms carbonic acid gas: when the diſengagement of theſe two acids has taken place, the nature of the albumen is ſingularly changed, it's conſtituent prin-

ciples no longer retain the ſame order or proportion in their compoſition; the reſult of which is, on the one ſide, the oxalic acid, on the other, a fatty or oily matter, of a citron colour, that ſwims in the ſame liquor; a green little malic acid is alſo obtained.

If the albumen coagulated by acids be diluted with water, the liquor filtered and evaporated, ſalts are obtained, the baſis of which is ſoda; hence the cauſe of the colour liquid albumen gives to violets.

It is alſo to the ſame ſalt, as well as to the phoſphat of ſoda and ammonia, found by analyſis to exiſt in albumen, that the precipitation of the above mentioned different ſalts ariſe. According to Fourcroy, the metallic precipitates carry with them a portion of it in it's oxygenated and concrete ſtate. It is likewiſe by decompoſing the phoſphat of ſoda, which is held in ſolution, that the precipitation by lime is produced.

By gently evaporating the water in which albumen has been diluted, after having obtained this laſt in a concrete form by heat, and ſeparated it from the lye, cryſtals of muriat of ſoda are obtained. To this it may be added, that it is often obſerved, on treating in this way ſeveral ſpecies of albumen, and amongſt others the ſerum of the blood, and that which exiſts in the muſcles, and is extracted by preſſure, that the liquor when properly evaporated, to obtain the cryſtallizable ſalts, becomes a jelly, on cooling: this phenomenon is only indicated here to ſhow, that the liquid albumen is often accompanied with another animal ſubſtance of equal importance; an account of which will be given in the next article, *Gelatin.*

From the analyſis of albumen, it appears to be compoſed of carbon, hydrogen, azot, and different propor- It's compoſition.

tions of oxygen, phosphoric and muriatic acids, soda, and lime.

Remarks upon albumen.

The name of albumen has been given to this matter, from it's analogy to the white of an egg, and in whatever part of the body it is formed, it's characters are inriably the same. This organic composed substance is very abundant in all animals, and forms a very distinct genus amongst the composed parts of organized bodies. The white of the egg, called albumen by the Latins, may be looked upon as the first species of this genus; and it was that, the analysis of which was first the means of discovering the striking analogy that exists between it and many other animal substances. The serum of the blood, the more or less thick and even concrete matter of the vitreous humour, and of the crystalline lens, a great part of the white humour which moves in the lymphatic or absorbent vessels, the water collected in the different cavities of the body distended by the dropsy, are the principal species of this genus; or to use a more exact method of expression, contain a very large proportion of albumen; whilst the greater part of the membranous and white organs, and especially the membranes which line the hollow viscera, as well as silk, contain more less of it in it's concrete state: in short, it is found even in the juices of vegetables. It's liquidity arises from it's always being combined in the fluids, of which it forms the principal basis, with a certain quantity of water; but on becoming an integrant part of the solid organs it is in a concrete state, and has in some measure changed it's nature and properties. It is certain, that the degree of heat, by which it is coagulated by chemical agents, cannot take place in the body, yet the formation and separation of most of it's organs require the slow fixation of oxygen, the combination of which, with the animal fluids, appears from the ex-

periments on reſpiration to take place in the lungs. It is, therefore, during it's circulation in the ſanguiferous and lymphatic veſſels, that the albumen abſorbs by degrees the oxygen, until it has received ſuch a quantity as to become concrete, which appears to be at the time it has arrived in the ultimate vaſcular ramifications which carry the nutriment to the ſolids; hence the neceſſity of changing it's nature, and inſtead of remaining liquid, to become concrete or oxygenated albumen; and as the variable quantities of the oxygen and water depend on the age and ſtate of health of animals, they produce a more or leſs ſtrong concreſcibility, or more or leſs decided fluidity of the albumen.

Albumen, according to the experiments of Hatchett, is the predominant and eſſential part in the tiſſue, or web of membrane, cartilage, ſponge, the horny ſtems of gorgoniæ, horn, hair, feather, quill, hoof, nail, horny ſcale, cruſt, and tortoiſe-ſhell; and although in all it has ſimilar chemical properties; yet in conſiſtence, it varies from a tender jelly-like ſubſtance, to a completely formed membrane, or to an elaſtic, brittle, hard body, like tortoiſe-ſhell; and he thinks, it is the original ſubſtance from which all theſe bodies as well as muſcular fibre derive their origin. He affirms, there is alſo much reaſon to believe, that gelatin, although it appears ſo different in many reſpects from albumen, is yet formed from it: for, from his experiments, it appears, that tortoiſe-ſhell, horn, muſcular fibre and inſpiſſated albumen, after long dilution in very dilute nitric acid, and after being well waſhed, were ſoluble in boiling water, and that a ſubſtance was formed, which (by becoming liquified when heated, by being ſoluble in boiling water, by being precipitated by the tanning principle, and by nitro-mutriat of tin; and laſtly, by forming a gelatinous maſs, when the aqueous ſolution was ſufficiently

evaporated and cooled, approached and resembled gelatin. He thinks it might perhaps be too hasty to assert that gelatin was absolutely thus formed; but if a substance so very similar to it could be thus produced, he is of opinion, that the real gelatin, with it's various modifications, is formed from albumen, by the more efficacious and delicate operations of nature.

In attempting to prove that albumen, or the coagulating lymph, is the original animal substance, this chemist has only stated chemical facts; but when the phenomena attending incubation are considered; when the experiments made by eminent physiologists, such as Haller, Maitre Jean, and Malpighi, are attended to; when the oviparous fœtus is seen to be progressively formed in and from the albumen of the egg, so that upon the bursting of the shell which separated it from external matter, the young animal comes forth complete in all it's parts; when such strong facts as these are corroborated by those which chemistry affords; it can scarcely be doubted, according to Hatchett, but that albumen is the primary substance from which the others are derived; and there is much reason to believe that the formation of gelatin, and of the animal fibre especially, begins with the process of sanguification in the fœtus.

This is by no means a novel opinion. It was supposed by Thouvenel, that animal albumen might be converted into animal jelly; and Fourcroy affirms, that gelatin only differs from albumen by containing a larger proportion of oxygen, and that since gelatin has a great tendency to become acid, it is a proof of it's having a greater quantity of oxygen in it's composition, which was only necessary to form that fermentation. This chemist is more particularly confirmed in his opinion, by finding that all vegetable substances which are acid, and fruits in particular, contain no albumen, whilst gelatin is con-

ſtantly obtained; on the contrary, thoſe which afford albumen, as all young vegetable ſubſtances do, ſhow no appearance of acidity. He has alſo obſerved, that the albumen of the blood forms with the nitric, muriatic, and acetous acids, a ſpecies of gelatin. Hence he ſuſpects that every jelly is a combination of the oxygenous principle and albumen. Such are the opinions of the preſent chemical phyſiologiſts on the converſion of albumen into gelatin.

From the properties which albumen poſſeſſes of being coagulated, it is made uſe of in the arts to clarify various fluid bodies. For this purpoſe, the blood of different animals is in general choſen, when any large quantity of clarifying albumen is wanted, this fluid containing it in large quantity, and being eaſily procured. When required in ſmall quantity, the albumen of the egg is generally preferred as being more delicate. It acts by uniting with, and entangling in it's compoſition as it coagulates, the impure parts of the fluid to be clarified, which it carries to the ſurface in the form of a hard ſcum, which being no longer ſoluble in it's coagulated ſtate, is eaſily taken out. This coagulating property is likewiſe of uſe in the art of anatomy, for when it has undergone this change by the muriatic or nitric acids, any heterogeneous parts it contains are more eaſily to be diſcerned. It was thus, that Reil diſcovered the nerves of the cryſtalline lens, and when thoſe worms which are denominated gelatinous have been immerſed a few ſeconds in either of the above acids, a fibrous ſtructure is obſerved, and the anatomiſt is enabled to diſtinguiſh and examine them.

GELATIN.

It's properties.

On boiling animal ſubſtances in water, a certain matter is extracted, which, on becoming cool, forms a ſolid and tremulous jelly, and from this property it has been called gelatin.

When pure, it is colourleſs and tranſparent, without ſmell, and of a mild ſavour. It is perfectly ſoluble in water, but does not coagulate as albumen does. It is likewiſe ſoluble in acids and alkalis, but leſs ſo in the laſt. With the nitric acid, a little azot is diſengaged, and a ſmall part is changed into fat, whilſt the greater part is converted into oxalic acid. Solutions of lime produce a precipitate of phoſphat of lime when poured into a ſolution of gelatin. With the principle of tan it forms a compound inſoluble in water; hence this principle is a very convenient reagent to aſcertain the preſence of gelatin in any fluid, and to determine with preciſion quantity. Thus, if the infuſion of tan be poured into milk, whey, ſerum, broth, &c. it forms a precipitate more or leſs abundant, according to the quantity of gelatin they contain. It is inſoluble in alcohol. If kept for ſome time, it undergoes the acetous fermentation from the ſaccharine matter it contains; and this is ſaid ſooner to take place in the gelatin of graminivorous animals; it afterward paſſes into the putrid fermentation, and gives carbonated ammoniacal gas.

By diſtillation in the water bath it affords an inſipid, inodorous phlegm; in proportion as it loſes it's water, it aſſumes the conſiſtence of and becomes *glue*, for which, vide *Soft Parts*; and when entirelydried, it reſembles horn. Expoſed to a ſtronger heat with acceſs of air, it ſwells, liquifies, and becomes black, emitting a great deal of

fetid ſmoke, which does not eaſily inflame. By a violent heat in a retort, it affords an alkaline phlegm, an empyreumatic oil, and a ſmall quantity of ammoniacal chalk; and leaves a large maſs of charcoal of difficult incineration, containing muriat of ſoda and calcareous phoſphat.

The component parts of gelatin are, therefore, carbon, hydrogen, azot, ſaccharine matter, phoſphoric acid, muriatic acid, lime, and ſoda. It's compoſition.

Gelatin is obtained from all the ſoft and white parts of animals in large quantity, ſuch as the membranous parts, tendons, ligaments, aponeuroſes, cartilages, horns, bones, and ſkins. It therefore appears to partake of the ſolidity of albumen in moſt of theſe parts, and as it forms the baſis of all of them, they are more or leſs ſuſceptible of being diſſolved by boiling water, and of forming tranſparent jellies on becoming cool. From experiments, it appears, that gelatin in moſt of it's properties bears a great reſemblance to thoſe of the inſipid vegetable mucilages, if we except thoſe that afford ammonia by heat and mephitis by the nitrous acid, which, from the opinion of Fourcroy, may be attributed to a portion of lymphatic matter or albumen, which the water extracts at the ſame time with the gelatin, particularly when jellies or glues have been prepared by ſtrong decoction, long continued. Remarks upon gelatin.

According to Hatchett, gelatin varies in it's degree of conſiſtence, and in making experiments on animal ſubſtances, he had frequent opportunities of obſerving the various degrees of viſcidity and tenacity which characterize it, and which he has noted by the different names of mucilage, ſize, and glue. In young animals the mucilage is more predominant, and it becomes diminiſhed as they increaſe in growth and age. Hence there is every reaſon to conclude, that the ſubſtance, which in very

young animals was at firft mucilaginous, becomes progreffively more vifcid, and affumes the characters of gelatin; mucilage is, therefore, the moft attenuated, and the loweft in order among the modifications of gelatin. Gelatin, he found, whether in the ftate of mucilage, fize, or glue, when completely dried, to be affected by water according to it's degree of acidity, and examined by the tanning principle, and nitro-muriat of tin; mucilage is more immediately affected by the latter than by the former, while the folutions of fize and glue are equally acted upon by both. When thefe three varieties are fteeped in nitric acid, with three or four parts of water, they alfo progreffively diffolve according to the degree of vifcidity by which they are feparately diftinguifhed. Gelatin, according to it's quantity and quality, has a powerful influence on fome of the phyfical and chemical properties of the bodies in which it is prefent, viz. on their flexibility, elafticity, and putrefcibility; for when bodies, fuch as mufcular fibre, membrane, fponge, hair, and cuticle, are deprived of gelatin, and dried in the air, they become rigid and brittle, and Hatchett has no doubt, but that this arifes from the lofs of the gelatinous fubftance; and as an additional proof, when bodies, fuch as nail, feather, quill, and tortoife-fhell, which contain little or no gelatin, are long boiled, and then dried in the air like the former, they are found to have fcarcely fuffered any alteration in their refpective degrees of flexibility and elafticity. As to putrefaction, it is obvious that certain parts are more fufceptible of it than others, thus the vifcera, mufcles and cutis, foon fuffer a change; while hair, feather, fcale, hoof, horn and nail remain unchanged for ages after the former have been decompofed; the caufe of this he attributes to the gelatin and moifture, which are combined in the former, and not in the latter in any notable quantity; for mucilage diffolv-

ed in water, he found to be the firſt, and glue the laſt that ſhowed ſymptoms of putrefaction. It is, therefore, the preſence of gelatin in various ſtates and proportions (including moiſture and organic arrangement) that is the principal cauſe of thoſe degrees of flexibility, of elaſticity, and of putreſcibility, ſo various in the different parts of animals.

FIBRIN.

The fibrous part of animals, when pure, is of a white colour, without ſmell or taſte; it is very tenacious, and capable of being lengthened. It is procured in this ſtate by waſhing the coagulated part of blood, when it remains in the form of white filaments of a very ſolid conſiſtence. It is inſoluble in water at all temperatures, and when boiled it hardens, and aſſumes a gray colour. The moſt weak acids diſſolve it. Diluted nitric acid, according to Berthollet, diſengages a larger quantity of azot gas from it than from any other animal ſubſtance, and by the aid of heat, it diſſolves it with effervеſcence, accompanied with nitrous gas; when all this gas is diſengaged, oily and ſaline flocks are obſerved in the reſiduum, floating in a yellowiſh liquor, which, on evaporation, affords cryſtals of oxalic acid, and a larger quantity of flocks, compoſed of a fatty matter, and phoſphat of lime is depoſited. Concentrated ſulphuric acid converts it partly into water, partly into acid. The muriatic acid diſſolves it, and forms with it a green jelly. The acetous likewiſe diſſolves it by the aid of heat. The fibrin is precipitated from the acids by the means of water, and more particularly by alkalis. During this combination with the acid, the fibrin is decompoſed, and when ſeparated, no longer

It's properties.

prefents the fame properties. It is not diffolved by alkalis in their diluted ftate; but when cauftic and concentrated, they attack it by the means of heat. Neutral falts, and mineral fubftances, have no effect upon it.

On being expofed to diftillation, it affords water of a faint fmell, an alkaline phlegm, a ponderous, thick, and very fetid oil, with much ammoniacal chalk. The remaining coal is not bulky, but compact and heavy; and is lefs difficult to incinerate than that of albumen. The afhes are very white, and contain neither faline matter, nor iron; their appearance being earthy, feem to confift of phofphat of lime.

The moft gentle heat fuddenly affects fibrin; it fhrinks into a fubftance refembling parchment, and when expofed to a ftrong heat, becomes like a piece of horn or bone; on being burnt, it crackles, and produces a very fetid fmell like the burning of feathers.

It putrefies with great facility, and being expofed to a hot and moift air, fwells, and affords a large quantity of volatile alkali.

The only parts that contain fibrin are the blood and the mufcles; in the firft it would appear to be in a ftate of folution, or at leaft in a very divided ftate, but poffeffing the remarkable property of becoming concrete on cooling and repofe, in which a fibrous texture is afterward very evident. In the fecond, it is condenfed, concreted, or perhaps to ufe a more appropriate expreffion, organized under the form of mufcular flefh; which, according to Fourcroy, ought to be confidered as the real refervoir of all the fibrin contained in the blood. In this view he looks upon the mufcles as certain organs, in which this animal matter is depofited, fo as to conftitute their bafis, forming the fubftance that is moft eminently irritable.

Fibrin, therefore, differs greatly from albumen; it is a

kind of animal gluten greatly resembling that of flour, and is more perfectly animalized than either albumen or gelatin, from it's possessing so great a proportion of azot. There is, however, reason to believe, that the principal difference between it and gelatin arises from it's containing a greater quantity of oxygen; and that the vital power, by causing the gelatin to combine with a larger proportion of the oxygenous principle, converts it into fibrin, or oxygenated gelatin: this conclusion is greatly supported by the observation of Seguin, who affirms, that substances capable of absorbing oxygen deprive the fibrous matter of it's solidity, and convert it into gelatin.

From the experiments of Hatchett, it appears, not only that albumen, gelatin, and fibrin, differ very much from each other in their relative proportions of saline or earthy residue, but also in the proportion of one of their essential elementary principles, which is carbon; and as in vegetables the fibrous part contains the largest proportion of carbon, so in animals, muscular fibre appears to contain the greatest quantity of it. It likewise far exceeds the others in it's proportion of azot. These three are however easily separated from each other by boiling water, whenever a substance containing them is exposed to it; the gelatin is dissolved, and may be precipitated by tan, the albumen is coagulated, and the fibrin remains unaffected.

Form various combinations.

From these three substances, *albumen*, *gelatin*, and *fibrin*, in a state of concretion, either singly or forming double or ternary combinations, and more especially from their different proportions, the organs of animals are formed. They likewise compose a great part of the animal fluids, particularly the albumen; in these, however, there is less oxygen and more water, and they are besides united with acids, neutral salts, phosphat of lime, &c. Gelatin is very sparingly found in the fluids, but abounds in the

solids, and it appears to receive it's gelatinous nature on passing from the first into the last. It is also more abundantly found in young animals; on the contrary, age is more adapted to the formation of fibrin, old animals containing a greater proportion of it. It is, however, the albumen that appears only to undergo any particular alteration from disease, at least in the blood. Parmentier and Deyeux affirm, that this change in the albumen became particularly sensible in the serum, which in a state of disease never acquired that complete concretion on exposure to heat, which always took place in healthy serum; but a certain quantity of liquid separated on simple decantation. The morbific action had no influence in these cases upon the gelatin or fibrin.

OSSEOUS MATTER.

The fourth substance that is joined to the above three in various parts of animals is the osseous matter; it forms a considerable part of the animal body, particularly of the solid organs, and is the great basis of support to the animal fabric. In young animals it is in small quantity, but increases in proportion to the age; and when an animal has obtained it's proper proportion of this osseous matter, it's organization is completed, whilst as age advances, a superabundant quantity is deposited in almost every part of the body, giving rise to the rigidity of the different organs; and as the fibrin in some measure gives place to it, the functions become greatly impaired; hence what was wanting to add solidity in infancy, and produce it in the adult, in old age, by it's great accumulation, renders the system incapable of acting with it's accustomed agility. Of all the parts of the body the bones

contain the largeft quantity of this matter, whence it has derived it's name of *offeous*; the original texture of thefe organs being membranous and porous like a fponge, the offeous matter is depofited in it, forming thofe hard pillars that fupport all the other parts of the animal machine. It is not, however, only prefent in the bones of man, quadrupeds, and birds, but alfo in thofe of fifh, and even in the fkeletons of infects. This offeous matter is an earthy falt, or the phofphat of lime, a nearly infoluble fubftance; for an account of which, vide *bones*.

The component parts, therefore, of animal fubftances, may be divided into two kinds, the proximate, and remote. Component parts, two kinds of.

1ft. The proximate parts, or thofe matters that may be feparated from animal fubftances, without their organization fuffering much change, are albumen, gelatin, fibrin, oils, acids, poifons, aromas, and colouring parts. 1. Proximate parts.

2d. The remote parts, or thofe ultimate component parts into which the proximate parts are decompofed, and beyond which chemical analyfis has not been able to penetrate, are oxygen, hydrogen, carbon, azot, foda, fulphur, phofphorus, lime, and iron; and it is from thefe in different proportions and combinations, that the very complex machine of animals is formed. 2. Remote parts.

On comparing animals with vegetables, they appear to be only a gradual feries from a more or lefs perfect fyftem of organization; and although the one may be eafily diftinguifhed from the other, in their more perfect forms, yet as we defcend towards thofe tribes that have been faid to form the limits between the two kingdoms, the difference feems to vanifh by degrees, and the animal organization is loft in that of the vegetable. There is great reafon to believe that this change, which is for the moft part external and phyfical, is equally gradual with Animal fubftances compared with vegetable.

respect to their component parts, so that their chemical analysis may in great measure corroborate the observations of the natural historian.

Difference between their proximate principles.

The difference that exists between the proximate principles of animals and vegetables consists either in their proportions or their varieties; thus

1st. Albumen in animals is found in large quantities, whilst the juices of vegetables contain very little of it.

2d. Gelatin in animals is much softer, not so easily dried, and has a stronger taste than in vegetables; it likewise attracts humidity from the air, and is more disposed to putrefy than in the last.

3d. Fibrin, in animals, though analogous to the gluten of flour, has more tenacity, and they contain it in larger quantity.

4th. Fixed oils, in animals, are more concrete, and more abundant than in vegetables; and, according to Berthollet possess different characters, for animal oils give, on distillation, an alkaline liquor, whilst the vegetable give an acid; on the contrary, the volatile oils and resins are more abundant in the vegetable tribes.

5th. Acids appear to form a great difference between the two kingdoms: for although some of the vegetable acids, as the oxalic, malic, benzoic, and acetous, are found in animals; and some of the animal acids, as the sebacic, the prussic, and the phosphoric in vegetables; yet they are in very small quantity, and the bombic, the formic, the lithic, the lactic, saccholactic, and the amniotic, are peculiar to animals only. The alkalis likewise are different; in the animal soda prevails, in the vegetable potash is predominant.

6th. Poisons are less abundant in animals than in vegetables, and their action is only on the blood, whilst vegetable poisons act on the stomach. Animal poisons likewise dispose the body to a more rapid putrefaction.

7th. Animal aromas are lefs agreeable, and lefs various than thofe of the vegetable kingdom.

8th. Animal colouring parts, on the contrary, are much more fplendid and beautiful than the vegetable ones.

9th. The difference in their remote parts likewife appears to arife more from their proportion than any new principles; but fince it is in thefe that chemifts have founded the diftinguifhing characters, it will be neceffary to give it more in detail. Between their remote parts.

The difference that conftitutes the effential character between animal and vegetable fubftances, when fubjected to analyfis, was but very imperfectly underftood before the experiments of Berthollet, to whom we are principally indebted for what is known on this fubject. It had, indeed, been obferved, that the action of fire, which was almoft the only chemical agent to which animal fubftances had been fubmitted, gave rife to products that were much more difagreeable in fmell than what arofe from vegetables, and that the ftench produced from them during putrefaction was likewife equally intolerable; but even Neumann, one of the moft enlightened of the chemifts of his time, feems not to have been aware of the principle that conftitutes the chief diftinction, or of the origin of the difgufting and naufeating effluvia. Ignorance of the old chemifts.

It had been obferved by fome chemifts, that animal fubftances were not, however, the only matters whofe fpontaneous or artificial analyfis by fire was fo intolerable; but that certain vegetables, particularly of the cruciform tribes, greatly refemble them. Hence Boerhaave divided plants into two claffes; in the *firft*, he placed thofe which afforded by diftillation water, an empyreumatic acid phlegm, a little carbonat of ammonia, and a charcoal. In the *fecond*, thofe which afforded a fetid water, a very fetid empyreumatic oil, carbonat of

ammonia, both in a dry and liquid form, and a charcoal of difficult incineration. The products of the laſt, it is evident, made them approach very near to thoſe which animal matters afford, and on this account they were called by Rouelle animal plants, as partaking of the animal nature; they form by much the ſmalleſt claſs, compriſing moſt of the acrid plants, ſuch as tobacco, ſneezewort, garlick, onions, muſtard, horſeradiſh, and all the cruciform plants, except the crambe tataria; the mulberry likewiſe belongs to this claſs. Beccaria diſcovered a ſubſtance that is nearly animalized in flour called gluten; and it was found, that phoſphorus, which Margraaf had already diſcovered in plants, always made a component part of them.

Reaſon of it.

Chemiſts were, however, ſtill ignorant of the reaſons of theſe differences, and it may be eaſily accounted for, on conſidering how little they were acquainted with the action of reagents on organized matters, and more particularly from their want of knowing the nature of the gaſeous fluids, for the diſcovery of the properties of which modern chemiſtry is ſo juſtly celebrated. Conjecture, however, ſupplied the place of facts; and it was attributed to the greater proportion of phlogiſton, and it's leſs firm combination with the other principles of animal matters than of vegetables, until Prieſtley made the diſcovery. He found, on treating vegetables with ſpirit of nitre, that beſides fixed air nitrous air was produced. On the contrary, animal ſubſtances treated in the ſame manner, inſtead of nitrous, afforded *phlogiſticated air*. Berthollet, taking advantage of this diſcovery, and extending his reſearches on the ſubject, found, that on eſtimating the reſults that aroſe from the analyſis of animal and vegetable matters, the principal difference between them was really owing to the air which Prieſtley had called phlogiſticated, and which he named, according to the new theory, azot

Diſcovered by Prieſtly.

Applied by Berthollet. Azot forms the great difference between the animal and vegetable world.

gas. Hence to the presence and proportion of *azot* in animal substances, and to the great quantity they in general contain are to be attributed,

1. Their property of affording a much larger quantity of ammonia than vegetables, and of giving such very fetid products.

2. Of affording a much larger quantity of azot gas, particularly when treated with the nitric acid.

3. Of affording a great deal of prussic acid.

4. Of contributing singularly to the formation of the nitric acid, while the remaining remote parts of organized beings contribute to make their division and difference still more evident; thus,

5. Oxygen, which is in very small quantity in animals, abounds in vegetables; on the contrary,

6. Hydrogen, phosphorus, and sulphur, are more abundant in animals, and it is from the different proportions of these parts that

Animals are more subject to the putrid fermentation;
Vegetables, to the spirituous fermentation:
Animals afford an alkali;
Vegetables an acid:
Animals have a coal of difficult incineration;
Vegetables, of easy incineration.

The predominancy of the quantity of *azot* in animal substances is therefore looked upon by chemists as the efficient cause, that more particularly distinguishes them from vegetables, more so than the greater or less proportion of any of their other remote parts; the simple vegetable is even said to be entirely without it, and to consist, according to Lavoisier, only of the three principles, oxygen, hydrogen, and carbon, azot being only present in those vegetables that are more or less animalized. Azot, however, exists in different proportions, even in animals. Gelatin affords the least quantity of it; albumen has it

in larger proportion; but of all the parts of an animal, the fibrin affords the moſt. It differs likewiſe, according to the age and ſpecies of the animal; thus the fleſh of young animals affords leſs than that of old, the difference amounting even to $\frac{1}{3}$. The fleſh of carnivorous animals gives ſomewhat more than that of the frugivorous claſs; fiſhes afford it more readily than quadrupeds, and it always is perfectly correſpondent to the quantity of ammonia produced by the action of fire.

Concluſion. From this principle being wanting in vegetables, it may be concluded, that if animal matters be deprived of it, they will, in ſome meaſure, be brought back to the ſtate of vegetable matter; and that to animalize the laſt, it is neceſſary to add azot: and this is effected by nature, in the firſt inſtance, in the decompoſition of animal bodies by putrefaction; and in the ſecond, when ſhe compoſes them by animalization. Chemiſtry, leſs perfect than nature, has arrived at preſent only at the means of performing the firſt proceſs, or of reducing them to a leſs complex ſtate by analyſis; to compound them again, or produce animal matters from vegetables by ſyntheſis, ſhe has at preſent been utterly incapable, the principle of life not being at her diſpoſal.

Fourcroy's Elements of Chemiſtry, vol. 4.—Anfangſgrunde der Chemie von G. Friedr. Hildebrandt, 3 b. Erlangen, 1794—Mémoires de l'Académie Impériale et Royale des Sciences et Belles Lettres à Bruxelles, par von Bochaute, tom. 4. 1783.—Berthollet ſur la Nature des Subſtances Animales & ſur leurs Rapports avec les Subſtances Végétales, Mém. de l'Acad. Royal. p. 331. An. 1785—Philoſophie Chimique, par A. F. Fourcroy. p. 13. ed. van Mons. Bruxelles. An. 3. de la République.—Mémoire ſur l'Exiſtence de la Matière Albumineuſe dans les Végétaux, par Mr. Fourcroy. Annal. de Chimie,

p. 252. tom. 3.—Récherches pour servir à l'Histoire du Gas Azote, ou de la Mofette, comme Principe des Matières Animales, par Monf. Fourcroy. Annal. de Chimie, v. 1. p. 40.—Experiments and Observations on different kinds of Air, &c. by Jos. Priestley, L. L. D. F. R. S. vol. iii. p. 17. 1790. Birmingham.—Chemical Experiments on Zoophytes, with some Observations on the Component Parts of Membrane, by Charles Hatchett, Esq. F. R. S. Phil. Trans. 1800.

APPENDIX.

THE parts of animals hitherto examined have, with very few exceptions, been taken from the human ſubject, and thoſe animals which Daubenton has placed amongſt the quadrupeds, and there now remains to give an account of the products that have been extracted from oviparous quadrupeds; ſerpents, inſects, and worms. The imperfect manner in which the analyſis of theſe four laſt claſſes has been made, prevents their being introduced in the preceding diviſion; for, as in general, the whole animal has been the ſubject of the proceſs, it would be impoſſible to aſcertain to what particular part the products obtained ought to be attributed.

OVIPAROUS QUADRUPEDS AND SERPENTS.

Oviparous quadrupeds and ſerpents.

THESE animals have in general a ſtronger odour or ſmell than the parts of that claſs of quadrupeds already examined; they are found to contain a much larger proportion of ſaline matter, affording a large quantity of volatile alkali, after having been triturated with oil of tartar, and ſubmitted to diſtillation by a gentle heat. Amongſt theſe, the tortoiſe, the frog, the toad, the lizard, the viper, and the ſnake, have been employed in medicine, either by regular practitioners, or by quacks; and great virtues have been attributed to them in the cure of different diſeaſes, but a more experienced age has nearly exploded their uſe.

It appears from the experiments of Thouvenel, that these animals, on analysis by heat, afforded a jelly which was more or less light and viscous; a pungent, bitter, and deliquescent extract; an albuminous concrescible substance; an ammoniacal salt; and an oily substance of a peculiar taste and smell, part of which was soluble in alcohol.

INSECTS. Insects.

ANTS.

This industrious animal, so noted for the care of it's eggs, by conveying them to receive the warmth of the sun, and carrying them off on his disappearance, or on the approach of rain, and so much celebrated for it's republican mode of government, has already presented a peculiar acid to the chemist, called the *formic acid*; it now remains to give an account of it's other properties. It appears to be an omnivorous animal, living on grain, the sweet juices of vegetables, and the fleshy parts of animals. From this last circumstance, the anatomist is furnished with an assistant, by which he may obtain the skeletons of small animals, worked in an exquisitely neat, beautiful, and perfect manner, and far surpassing any thing than can be executed by the art of man. The animal, whether frog or mouse, must be enclosed, for this purpose, in a wooden, or other box, perforated with a number of holes, and placed in or near an ant-hillock; and it will be found, that in a few days every part of the animal will have been devoured except the bones and ligaments. Ants.

This animal has been supposed to furnish a substance

of a resinous nature, formerly used in medicine, and thought to possess peculiar virtues; it is found in pieces, on searching the ant-hill, and was distinguished by the names of wild frankincense, suffimentum silvestre, thus germanicum, mastix, and electrum formicarum; but on a more exact examination, it appears to be nothing else than the common resin of the fir, at the roots of the old trees of which these animals generally lodge; their reason, however, for collecting it, is unknown. According to Neumann, ants are destroyed by strewing a large quantity of unslacked lime about their hills.

Neumann, in his analysis of this insect by heat, distilled two parcels in a retort; the one consisted of ants, from which water had been previously extracted in baln. mar., then exsiccated; the other parcel was composed of fresh ants. Twenty-four ounces of the first afforded him four ounces and half of empyreumatic oil, three ounces and half of urinous spirit, two drachms and half of concrete volatile salt, one drachm of fixed alkaline salt, and eight ounces of earth; whilst no acidity was observed during the process. The same quantity of the second afforded eleven ounces two drachms of an acid spirit, six ounces six drachms of an urinous spirit, one ounce and half of empyreumatic oil, one drachm and half of concrete volatile salt, and nearly three ounces of earth remained, which gave half a scruple of fixed salt. Another circumstance, besides that of the total elevation of the acid by distillation, even in baln. mar., occurred to this chemist, for having extracted some spirit of wine from a quantity of ants, and cohobated the spirit upon two or three fresh parcels, he found swimming upon the distilled liquor a fine, clear, essential oil, a phenomenon extremely rare in the animal kingdom, and which was corroborated by obtaining the same by distillation with water. This essential volatile oil, obtained by digestion

with the ſpirit of wine, forms the ſpirit of magnanimity of Hoffmann. This æthereal oil was already known to Sperling. Margraaf likewiſe obtained it; but Rouelle was ſcarcely able to obſerve a trace of it; twelve ounces only gave him a drop. Hermbſtadt, on diſtilling ſixteen ounces of ants with three times the quantity of water, obtained one drachm ſix grains of it. According to Thouvenel, ants on analyſis afford products ſimilar to bodies from the vegetable kingdom. 1ſt. A very ſharp volatile acid. 2d. A volatile oil, reſembling the eſſential oil of plants. 3d. A fat oil, which is not attacked by alcohol, and reſembles fat vegetable oil. 4th. An extractive matter, partly ſoluble in water, partly in alcohol. 5th. A web or ſhining ſubſtance, without taſte or ſmell, which ſlightly tinges ſpirit of wine, and the nature of which is not known.

From the experiments on ants, it appears, that they conſiſt of an acid, which is very volatile; an eſſential oil extracted by alcohol in very ſmall quantity; a fixed oil, three drachms of which are extracted by boiling, and then preſſure, from one pound of ants, which is of a greeniſh yellow colour, congeals at a much warmer temperature than olive oil, and which reſembles wax; and an extract: this laſt is taken from the evaporated decoction, is of a reddiſh brown colour, has a fetid odour, is acid, bitter, and nauſeous to the taſte, of a caſeous conſiſtence, and is ſeparated into two parts by the ſucceſſive application of water and alcohol. The parenchyma of the animal, deprived of theſe ſubſtances, amounts nearly to three ounces two drachms per pound.

CANTHARIDES.

THIS ſpecies of inſect is well known from it's ſtimulating property of raiſing bliſters, and hence it is employed in the practice of medicine. It is of a bright ſhining, greeniſh, golden colour, with a blueiſh hue. Cantharides were formerly brought from Spain, and hence obtained the appellation of Spaniſh Flies, but they are produced in great numbers in France, Germany, and other parts of the continent. It is principally from the aſh and the poplar they are collected. The uſual method of killing them, according to Neumann, is by the ſteam of diſtilled or ſtrong vinegar; but Lewis obſerves, that vinous ſpirits, as they are uſed for the curation of millepedes, are much better calculated for the deſtruction of cantharides, as well as of all other inſects; for the ſteam of alcohol, or the liquor itſelf, when ſprinkled upon them, is not only an immediate deſtroyer, but has likewiſe the property of preſerving them from decay. The flies are afterward dried, and made into parcels, ſo as to be ſecured from the air. By long keeping, however, they fall by degrees into a grayiſh or browniſh powder, and in this ſtate are unfit for uſe, their intrinſic quality being found to periſh with their external form. The moſt durable are the wings, which remain entire after the body of the inſect has mouldered into duſt.

Cantharides, when freſh, have a ſtrong fetid ſmell; when applied to the tongue, they make no impreſſion upon it, but in a ſhort time a degree of acrimony and a kind of pitchy taſte are diſcovered. Applied to the ſkin, they raiſe a bliſter upon the part. The ſtimulating power of this inſect has been attributed to an acrimonious cauſtic ſalt; but according to Neumann, experiment does

not discover any saline principle to be present in their composition, since the action of a strong heat produces only the same volatile alkali common to all animal substances. They communicate all their activity to vinous spirits, without losing any of their form, and their native principles Neumann affirms to be a resinous, a gelatinous, and an earthy matter, whilst the principle in which their activity solely and wholly resides is the resin. This resinous extract is acrid and nauseous to the taste, and blisters the skin like the fly in substance, whilst the gelatinous matter freed from the resinous, is, like the earthy part, insipid and inactive. On distillation, this chemist obtained on an open fire, from three ounces of the insect, one ounce of urinous spirit, two drachms of empyreumatic oil, and two drachms ten grains of volatile salt. The caput mortuum weighed ten drachms, and when calcined, and elixated, scarcely afforded one grain of saline matter.

According to Lewis, this insect communicates nothing of it's fine green colour either to water or spirit of wine. It renders the first of a muddy, yellowish, or brownish colour, and is deprived considerably of it's beauty. The second it renders of a bright yellow, and itself becomes more beautiful and brighter than before. The active part is equally extracted by both menstrua, the gelatinous substance rendering the other soluble in water, the same as the gummy parts of vegetables do the resinous. Extracts made from them, according to this chemist, blistered equally alike, and as effectually as the cantharides in substance, but the two residua were equally inactive.

According to the experiments of Thouvenel, cantharides consist, 1st. Of a parenchyma, the nature and properties of which he has not determined, and which amounts to half the weight of the dried insect. 2d. Of one fourth

of a reddiſh bitter extractive matter, reſembling that of ants, and which affords an acid on diſtillation. 3d. A ſmall quantity, amounting to about twelve grains in the ounce, of a yellow, oily, or rather wax-like matter, which produces the golden yellow colour of the inſect. 4th. Sixty grains of a green oily ſubſtance, analogous to wax, of a ſharp taſte, and in which the odour of this inſect principally reſides.

This ſubſtance, on diſtillation, gives a very penetrating acid, and a concrete oil, reſembling wax. Water diſſolves the extract, the yellow oil, and even a little of the green oil; but ether attacks only this laſt, and may be ſucceſsfully employed to ſeparate it from the others. The virtue of the cantharides ſeems to depend on this kind of green wax. Many experiments have convinced this chemiſt, that the extract ſo envelopes the oily part, as not to be entirely ſoluble in ſpirit of wine; hence to obtain this laſt at the ſame time with the extractive matter, ſo as to form in general a tincture well charged with theſe inſects, it is neceſſary to uſe equal parts of alcohol and water mixed together. On diſtilling this mixed tincture, the alcohol that is extracted preſerves a ſlight odour of the cantharides, and the different matters it held in ſolution ſeparate from each other in proportion as the evaporation goes forward.

From bees and waſps this chemiſt obtained likewiſe a fat matter reſembling wax, but the extract he found to differ from that of ants only in taſte and colour. With reſpect to the May bugs, (meloe proſcarabeus & maialis) according to Geoffroy, they contain much oil and volatile ſalt; and Thouvenel obtained from them a very ſtinking fluid, a colouring matter, an extract, and a fat ſubſtance that diſſolved in alcohol and ether. This laſt he found to act particularly on the ſkin.

According to Accum, the yellow matter depoſited in

veſſels containing *ſpiders*, preſerved in alcohol, is a true wax, and it may be obtained from theſe animals by gently heating them.

WOODLICE.

We are informed by Neumann, that on diſtillation of theſe inſects, watery liquors extract conſiderably more that ſpirituous. It had been commonly ſuppoſed that this inſect contained a nitrous ſalt, from it's living in cellars, and other places impregnated with nitre; and hence it was uſed in medicine in different diſeaſes; but this chemiſt was not able to extract any of this ſalt by analyſis. A more exact examination of theſe inſects has been made by Thouvenel, which preſented him with peculiar properties. By diſtillation on the water bath, without addition, he found them to afford an inſipid and alkaline phlegm, ſometimes efferveſcing with acids, and changing violet ſirup green; in this operation, they loſt five eighths of their weight. Treated afterward with water and alcohol, they afforded two drachms of ſoluble matter in the ounce, of which more than two thirds was extractive matter, and there remained an oily or waxy ſubſtance. Theſe two products are eaſily ſeparated by ether, which diſſolves the laſt without touching the extract. Theſe matters differ from thoſe of ants and cantharides, by affording more carbonat of ammonia, and no acid in diſtillation, &c. It is obſerved by this chemiſt, that amongſt inſects, the woodlice appear to have the ſame relation to ants and cantharides, that oviparous quadrupeds and ſerpents have with reſpect to real or viparous quadrupeds. The neutral ſalts contained in theſe inſects are very ſmall in quantity, and difficult to extract. He obtained, however, muriats of lime and of potaſh.

WORMS.

Worms. EARTH worms, or lumbrici, are the inhabitants more particularly of moist fat grounds, and are not fond of dry sands, in which they are rarely or never seen; after rain, they rise to the surface to enjoy the moisture, when they fall a prey to different birds, and this is the best time of collecting them. Reaumur proposes their collection in order to feed domestic fowls instead of grain, computing that they exceed in quantity that of every kind of grain reaped by man. They were formerly used in medicine, but as they soon become putrid on account of their copious slimy juice, it is necessary for preservation immediately to dry them either before the fire or sun. We are informed by Neumann, that if these earth-worms be moistened with wine or vinous spirits, to prevent their putrefaction, and placed in a wide mouthed glass, in a cellar, they are in a few days almost wholly resolved into a slimy liquor. He found that on digestion of fresh worms, in water or rectified spirit, the quantity of extract obtained from the first is not only greater in quantity than from the second, but the collective quantity extracted by both menstrua was greater when water, than when spirit was first applied. He found, that watery liquors extracted likewise more from woodlice, and considerably more than spirituous ones, although the quantity of matter, soluble in either, was not nearly so large in them as in the earth worm. When dried, and distilled in an open fire, they afforded him a volatile urinous spirit, concrete volatile salt, empyreumatic oil, and the remainder, after incineration and lixiviation, gave a fixed alkaline salt. If putrid before distillation, the product is almost merely a phlegm, or only a very little

oil, and volatile ſalt. According to Thouvenel, earth-worms, as well as woodlice, conſtantly afforded him the muriats of lime and of potaſh, whilſt in ants and cantharides theſe two baſes, the firſt of which always appeared to him to be more abundant, are united to an acid, which has the character of the phoſphoric. It is neceſſary however to obſerve, that this chemiſt has neither deſcribed the methods of extracting theſe ſalts, nor the proceſſes he employed to aſcertain their nature.

Neumann's Chemiſtry by Lewis.—Thouvenel Analyſe des Inſectes, Hiſt. de la Société de Médecine de Paris, p. 331. 1776.—Fourcroy's Elémens, tom. 4. 4th edit. Paris, 1791.

END OF VOL. II.

Printed by J. Crowder and E. Hemſted, Warwick-Square.